CHAPTER I

BASIC DESCRIPTION

A. Background Information

1. Location

U.S. Naval Pacific Meteorology and Oceanography Detachment, (NAVPACMETOC DET) Kadena lies at 26.21N latitude and 127.46E longitude, with a field elevation of 157 feet. Kadena AFB is host to Commander, Fleet Activities Okinawa / Naval Air Facility.

Originally commissioned as the Naval Weather Service Environmental Detachment (NWSED) in Naha. The Detachment was relocated to Kadena AFB on 10 May 1975 as part of the Fleet Activities, Naha relocation. Soon after, the Detachment was renamed Naval Oceanographic Command Detachment. On 1 October 1993, another name change resulted in the Detachments current title, U.S. Naval Pacific Meteorology and Oceanography Detachment (NPMOD). NPMOD occupies spaces on the first deck of building 3674, situated just north of the Navy flight line and base runway complex.

2. Physical Description of the Ryukyu Islands

Also known as the Nansei-Shoto Islands, the Ryukyu Island chain forms a 750 mile arc between Japan's southernmost main island of Kyushu and the northernmost tip of the island of Taiwan, or Formosa. Although the Ryukyu chain is comprised of 140 islands in eleven groupings, only the Amamioshima group in the north, the Sakishima group in the south, and the Okinawajima group in the center contain any considerable land area or population.

The island chain forms a natural boundary between the East China Sea to the west and the Pacific Ocean to the east. The boundary becomes especially evident when one examines the area’s bathymetry. Along the axis of the island arc, the shallow, flat, featureless plain of the East China Sea gives way to the deep and roughly contoured basin of the Pacific Ocean.

Geologically, these islands are located in an extremely active region. Examining global plate tectonics, the Ryukyu Trench east of the islands marks the location where the leading edge of the Philippine plate is being actively subducted beneath the trailing edge of the Asiatic plate. As a result, volcanic activity and earthquakes, both major and minor, are relatively common occurrences. In fact, these very phenomena are responsible for the creation of the Ryukyu Island chain.

Although at first glance the Ryukyu Islands appear to be a natural extension of the Japanese main islands, they are not. While the axes of both the Japanese and Ryukyu Island chains are similarly situated, roughly southwest to northeast, and their origins are similar, there the resemblance ends.

Due to a transverse trench north of Amamioshima, the Ryukyu Islands have never been connected to the main Japanese islands. In fact, the Islands were once connected to the Asian mainland by a land bridge.

Sea-level changes during the Pleistocene epoch have covered and uncovered the islands on at least four occasions. Evidence includes the massive coral formations found on the higher hills of Okinawa and Miyako-Jima. Of interest is the fact that, although the Ryukyu Islands are of volcanic origin, most geological formations now found on the islands are the result of reef-building coral.

A description of the Ryukyu Islands would not be complete without a mention of the Kuroshio Current. The Kuroshio Current is a warm, western boundary current in the vicinity of Okinawa, the Kuroshio is approximately 150 to 180 miles wide and flows with an average speed of one to two knots. The current either straddles Okinawa or lies in close proximity during the entire year, modifying the island's climate so extreme temperatures are not experienced.

3. <u>Physical Description of Okinawa</u>

Okinawa, the largest of the Ryukyu Islands, is situated southwest to northeast, and is approximately 65 miles in length. Its width varies from two to sixteen miles, and the narrowest point divides the southern third from the northern two-thirds. The northern two-thirds consists of rugged, hilly terrain covered with lush forest vegetation. The average elevation of this portion is 1,500 feet, with several points above 1,600 feet. The southern third consists of coral escarpments, cultivated patches, small rolling hills of less than 600 feet, and ridges that run perpendicular to the axis of the island.

Kadena Air Base is located near the midpoint of Okinawa, just slightly west of the center of the island. North-northwest of Kadena is a small plateau on which the Yomitan auxiliary airstrip is located. Directly north is “radar hill”, with an elevation of 734 feet. To the south, Naha (Okinawa’s Capital City) is visible along the western coast of Okinawa, while to the west, the East China Sea is less than a mile from the base.

Kadena Air Base has two principal runways, both running parallel to each other and oriented 050 degrees to 230 degrees magnetic. Runway designations are then made concerning relative location, either right or left. Runway 23R/05L is 12,100 feet long and 300 feet wide. The elevation at its northeast end is 132 feet, with no overrun, while at its southwest end, it is 66 feet above sea level with a thousand-foot overrun. Runway 23L/05R is also 12,100 feet long, but is only 200 feet wide. At the northeast end, it is 136 feet above sea level, while at its southwest end, the elevation is 77 feet. Each end of this runway has a thousand foot overrun.

4. <u>Area of Responsibility (AOR)</u>

a. The AOR for NPMOD Kadena is quite extensive. It includes the Sea of Japan, Yellow Sea, East China Sea, Western Pacific, South China Sea, Philippine Sea, and southern Pacific areas.

5. Commands Supported and Services provided by NPMOD Kadena

a. Because of its co-location on Kadena Air Base, NPMOD Kadena is not a full-service Detachment. The primary function of the Detachment is to provide meteorological and oceanographic (METOC) support to PATWING ONE DET Kadena / Commander, Task Group SEVEN TWO PT TWO and transient patrol aircraft. The Kadena Air Base Weather Station, manned by personnel of the 18th Operations Support Squadron, (18th OSS), is the official reporting station for the base.

As such, the 18th OSS performs many of the aviation and meteorological functions that otherwise would be performed by NPMOD. These include taking and reporting official synoptic observations, issuing the official Terminal Aerodrome Forecast (TAF), area weather warnings, base weather advisories, and providing DD175-1 aviation weather briefings and Horizontal Weather Depictions to all aircraft operating from Kadena AB.

b. NPMOD Kadena provides the following services:

(1) 72 hour OPAREA Forecast: Produced daily and includes synoptic discussion, sky condition, weather, visibility, surface winds, maximum and minimum temperatures, and rainfall data.

(2) Tropical Cyclone Conditions of Readiness (TCCOR) and Staff Briefings. A tropical cyclone exercise is held annually to prepare and familiarize all local U.S. Navy activities with tropical cyclone warnings, COR coordination and individual responsibilities for obtaining Conditions of Readiness upon request. Tropical cyclone briefs are held on a single command basis. During actual threats of tropical cyclones, NPMOD Kadena briefs Commander, Fleet Activities Okinawa, and is prepared to make TCCOR recommendations if naval assets stand a risk of damage or injury. Further discussion on TCCOR settings can be found in chapter II.

(3) Acoustic Range Prediction Forecasts. Produced on a daily basis for 24-hour ready briefs and upon request for real-time tactical missions.

(4) Integrated Refractive Effects Prediction System (IREPS). Electromagnetic range prediction forecasts are produced daily and on request. Also provide Electro-Optic range predictions upon request.

(5) Staff METOC briefs.

(a) Commander, Fleet Activities Okinawa (CFAO). A weekly brief comprised of a 72 hour forecast for Kadena, 24 hour regional forecast for specific aviation stations throughout mainland Japan, and any severe weather in the AOR.

(b) Commander, Task Group 72.2 (CTG 72.2). A bi-weekly brief comprised of a 72 hour forecast for Kadena, 24 hour regional forecast for specific aviation stations throughout mainland Japan, and any severe weather in the AOR.

(6) Optimum Path Aircraft Routing System (OPARS). Upon request.

(7) Climatological information and studies.

(8) Navy unique environmental products are provided via the Detachment's homepage to include: Local wind and wave height / direction, Astronomical data (Solar / Lunar rise, set, illumination and tides).

c. NPMOD supports the following commands:

(1) Patrol Wing One Detachment / Commander, Task Group 72.2.

(2) Commander, Fleet Activities Okinawa / Naval Air Facility Kadena.

(3) Japanese Maritime Self Defense Force Patrol Squadron, Naha.

(4) Commander, Task Force 76 (CTF 76). Provide METOC briefs for all amphibious assets in the AOR during CTF 76 Staff Oceanographer's absence.

(5) Naval Mobile Construction Battalion, Camp Shields

(6) Third Marine Expeditionary Force (III MEF)

(7) Mobile Mine Assembly Group Unit 10

(8) Military Sealift Command Naha, Okinawa

(9) White Beach Port Facility

(10) 320th Special Tactics Squadron

(11) Deployed SEAL Team

6. <u>METOC Communications and Equipment</u>

a. Meteorology and Oceanography Integrated Data Display System (MIDDS). A multi-tasking, dual pentium workstation providing three primary functions.

(1) Workstation where METOC personnel retrieve, process, and display various weather products.

(2) A briefing station with high quality graphics and enhancement features.

(3) Distributes METOC products locally and globally over BBS or LAN.

b. Primary sources of data utilized in operational METOC forecasting:

(1) NIPRNET (Unclassified) / SIPRNET (Classified)

(2) NODDS / JMV. A 56K data stream linked to FNMOC Monterey

(3) World Wide Web (www). A 56K connectivity links to various Civilian and DOD sources for METOC, tactical, and general information.

c. METOC Facsimile. A JMH (Japanese Meteorological Agency) broadcast that is received via HF radio receiver using various frequencies. The signal is transmitted from Tokyo and when received, converted and stored by MIDDS and displayed on the "Wall of Thunder".

d. Circuits

(1) Automated Weather Network (AWN) circuits linked to an Automated Digital Weather Switch (ADWS) originating from Tinker AFB, Oklahoma and relayed through communication centers in Hickam AFB, Hawaii, Yokota AFB, Japan, and Kadena AFB, before reaching it's destination within the Detachment.

(2) JQGAK4AX Circuit. AWN data routed into MIDDS, which automates the reception, retrieval, storing, editing, and transmission of weather information.

e. Tactical Environmental Support System (TESS, AN/UMK-3). TESS provides comprehensive environmental data communications, processing, and display capabilities designed to provide Navy tactical commanders with secure, responsive, and robust environmental support.

f. Satellite Receiving Equipment

(1) GSIDS provides enhanced manipulation of the GMS-5 imagery including magnification and looping capability via MIDDS.

(2) SMQ-11 Satellite Receiver System

CHAPTER II

CLIMATOLOGY

A. Atmospheric Climatology

1. General Circulation

Okinawa lies in the zone separating earth's largest landmass from its largest ocean. The different properties of each air mass are responsible, in a large part, for the general atmospheric circulation over the Far East (Cold and dry, the air mass generated by the Siberian high, versus warm and moist, the air mass generated by the Pacific high. The proximity and movement of these two primary air masses generate the large-scale monsoon flow, which dominates the region). Successful forecasting for the Okinawa area is dependent on two schools of thought. In the winter, the island experiences mid-latitude weather systems. It requires a firm understanding of polar front activity in a highly dynamic atmosphere from the surface to 50,000 feet. In the summer, tropical weather forecasting becomes the main staple for success as the mean position of the polar front relocates to the north, running from Shanghai into southern Japan, and into Honshu.

During the winter, the Siberian high is firmly established, inducing northeasterly flow, better known as the northeast monsoon over the Okinawa area. These cold air outbreaks are identified by the strong polar cold fronts, which mark their leading edges. The Pacific high is weak and has retreated southeast influencing the southwestern United States.

Spring is a three to four week transition from winter to summer, also known as the rainy season. With its approach, temperatures over Asia and Siberia become more moderate as the Siberian high weakens, receding to the northwest. At the same time, a heat low develops in Manchuria, and the Pacific high begins to build into the Far East. As a result, the polar front starts to migrate north. A broad line of convective activity develops along the northwestern edge of the Pacific high, which is often analyzed as a stationary front. This is referred to as the Transitional Convergence Zone. This line of clouds is a wind shear line caused by the low-level convergence of the diminishing northeasterly monsoon flow interacting with the southwesterly flow from the building North Pacific high. This marks the beginning of the rainy season.

By July, the Pacific high has reached its maximum intensity, bringing southwesterly winds, known as the southwest monsoon, and moist tropical air into the region. Throughout the summer months, the Pacific high will build into eastern China, providing fair weather for Okinawa, and weaken to just east of Okinawa, resulting in inclement weather. As this pulsing effect takes place, another wind shear line, known as Taiwan Convergence, develops along the western edge of the Pacific high. It is caused by the low-level convergence of the southwesterly monsoon flow from southern Asia and the southeasterly flow from the Pacific high. A favored area for cyclogenesis, unstable waves will develop southwest of Okinawa and mature southeast of Kyushu, following a track roughly parallel to the Kuroshio current. The North Pacific high (ridge) also provides the steering flow for tropical cyclones in the region.

During the autumn months, a weak high appears over Asia and the Pacific high begins to recede to its winter location. The Transitional Convergence Zone experienced in spring reoccurs, resulting in a shorter, less intense rainy season, which lasts for two to three weeks. By December, the Northeast monsoon has reestablished itself and the cycle begins anew.

2. <u>Resident Air Masses</u>

Although three principal air masses, continental polar (cP), maritime tropical (mT), and maritime polar (mP), dominate the northwest Pacific, only two of these, cP and mT, directly affect Okinawa's weather. Separated from each other by the atmospheric polar front the positional shifts of these air masses are directly responsible for most of the island's weather patterns. See Figure 2-1a. Monthly Migration of the Primary Polar Front.

a. Continental Polar (cP). This extremely cold, dry air mass originates over Siberia and pushes eastward, dominating the region during winter. At its source, a strong low level inversion usually exists. As it flows southeasterly, the cP air picks up heat from the earth's surface, warming by as much as 25 F by the time it reaches the ocean area. Upon reaching the ocean, it continues to extract warmth from the ocean surface and begins to acquire considerable moisture. As it moves over the warm Kuroshio waters, further warming and moisture acquisition will intensify the original convective instability of the air mass. Decks of stratus and stratocumulus are frequently the result. Warm Core Eddies which break-off from the Kuroshio and drift aimlessly west of Okinawa will have the same effect, stratus and stratocumulus, for up to five days. In the winter and spring months, this air mass is often drawn into the area by polar outbreaks.

b. Maritime Tropical (mT). During the summer, mT air dominates the Okinawa area. The southwest monsoon sets up as the subtropical high begins its seasonal journey westward, dominating the western Pacific and advecting very warm, moist air into the local region. Anti-cyclonic air flowing around the southern portion of the subtropical high picks up heat and moisture during its long over-water trajectory. Convective instability results when this air mass begins to move northward along the western edge of the subtropical air mass. These are ideal conditions for the formation of towering cumulus and cumulonimbus clouds, which dot the region.

3. <u>Jet Stream and Associated Phenomena</u>

Following the position of the atmospheric fronts, the jet stream is a phenomenon of importance in the Okinawa area. Seasonally variable, the strength and position of the atmospheric jet streams are directly proportional to the strength of the atmospheric fronts and the air masses from which they are generated.

During the winter, two jet streams cross the area. The subtropical jet extends latitudinally from the Himalayas through south central China to southern Japan and points eastward. Vertically centered at 150 to 200 MB with a typical strength of 165 knots, it exhibits little latitudinal variation, being primarily associated with the southern edge of the polar air mass. In contrast, the polar jet fluctuates over a large latitude zone, being primarily associated with migratory cyclonic systems. Vertically centered at 200 to 300 MB, it typically extends from Siberia north of the Tibetan plateau, through the Chinese coast at 40 degrees North, 120 degrees East. During the summer, these strong jet streams weaken to become a poorly defined zone of enhanced westerly winds.

A strong correlation exists between the trajectory of the jet streams and the mean path of surface cyclones. The subtropical jet stream passes above the polar jet (giving the appearance of converging) over the Yellow Sea during the winter. While the resultant combination jet remains south of most migratory cyclone tracks, it provides the impetus and energy for continued maintenance of surface cyclone systems. As an upper-level ridge, with its associated surface anti-cyclone, moves into a region, the jet ascends and loses strength. As polar outbreaks begin to occur, the jets "split" and appear as multiple jet streaks. See Figures 2-2a and 2-2b. Mean Position of the Winter and Summer Jet Stream Axis and the Zone of Extratropical Cyclone Movement.

4. Migratory Extratropical Cyclones and Associated Weather

Inclement weather experienced on Okinawa (with exception to the rainy season) during spring, winter, and autumn is largely caused by migratory low pressure systems that track through the region. These systems fall into six primary categories, identified by their trajectories and areas of origin. The categories can then be further identified as northern or southern; northern lows pass to the north of central Japan, while southern lows pass through or to the south of central Japan. See Figure 2-1b. Mean Migratory Storm Tracks.

a. Northern lows. Generally formed in southern Russia or northern China, these lows move from their source region across the Sea of Japan, over Hokkaido or Honshu, and into the Sea of Okhotsk or the northern Pacific, respectively. Northern lows generally do not directly affect Okinawa, and are of concern only because their passage may induce a southern low to form or significantly degrade aviation weather conditions in mainland Japan.

(1) South Mongolia low. Southern most of the northern group, these lows are the most common of any northern type. They can be expected to develop in all seasons, and move at an average speed of 20 knots. Frontal passage over Okinawa from this type of low is extremely rare, but cyclogenesis of a southern low from the passage of a South Mongolian low system is a strong possibility.

(2). Lake Baikal low. Most commonly occurring in the spring months, this type of low is possible year-round. These possess a generally parabolic path, initially

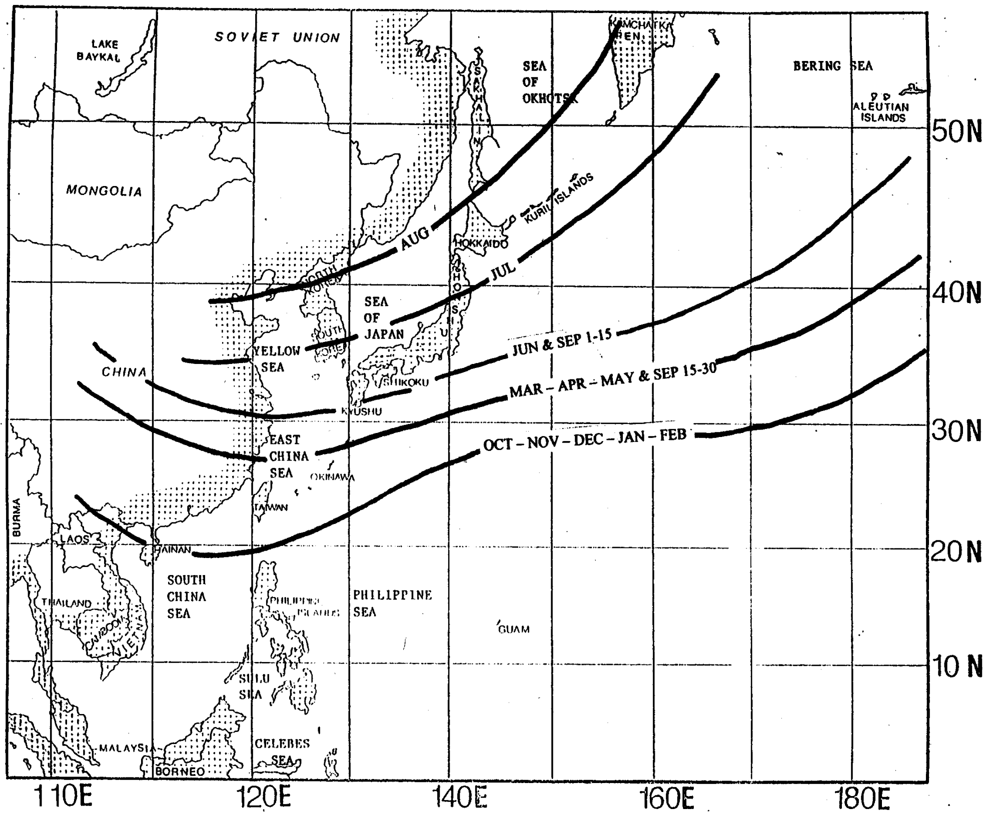

Figure 2-1a. Monthly Migration of the Primary Polar Front

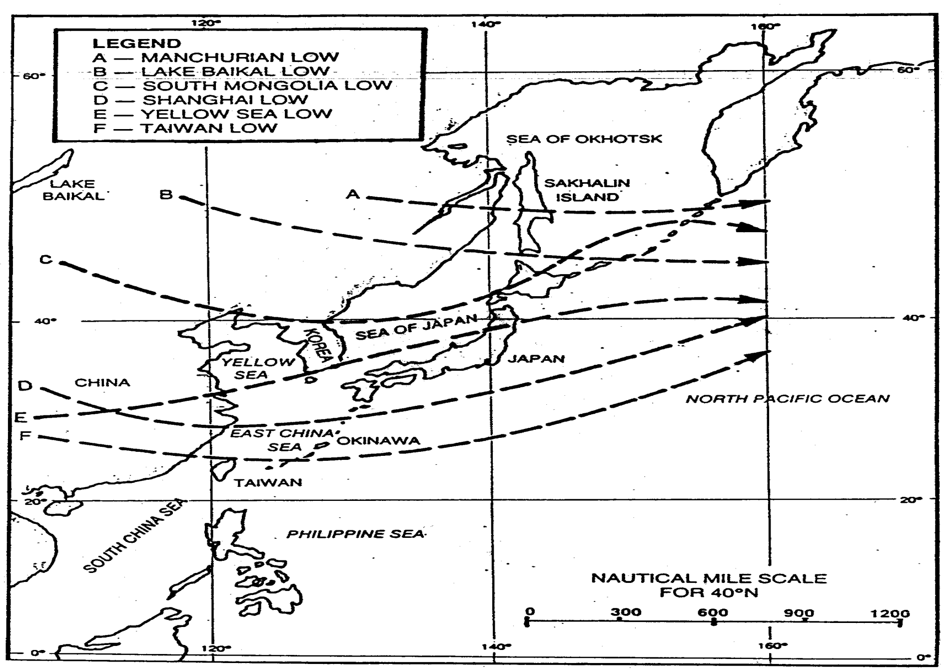

Figure 2-1b. Mean Migratory Storm Tracks

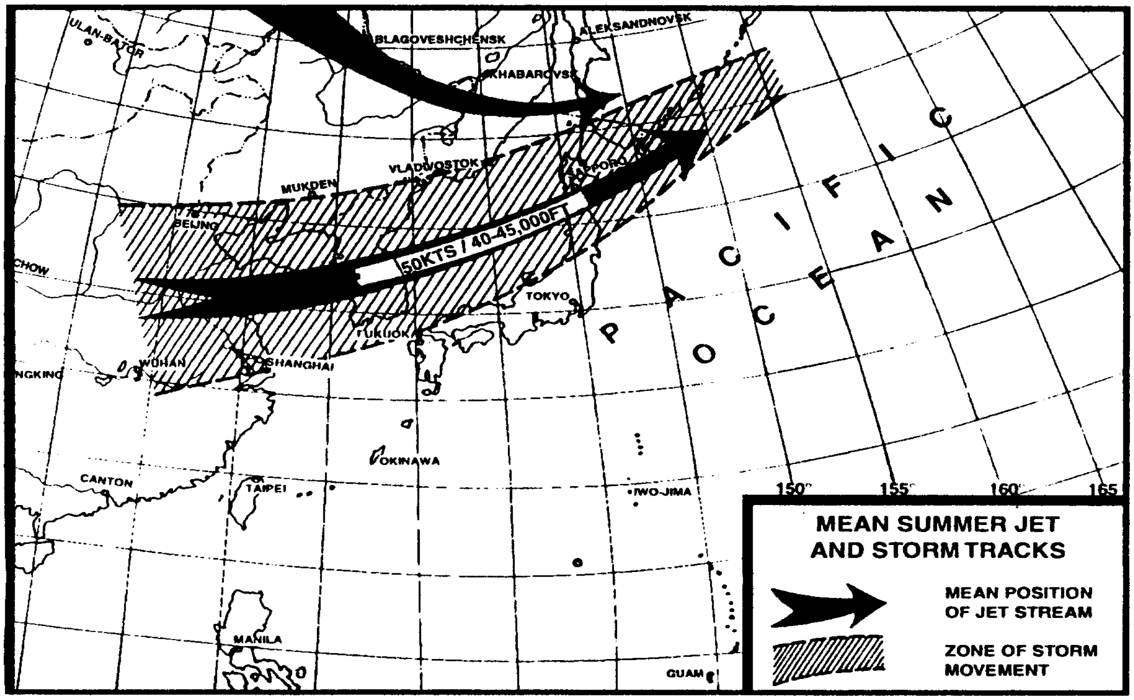

Figure 2-2a. Mean Position of Summer Jet Axis and Zone of Storm Movement

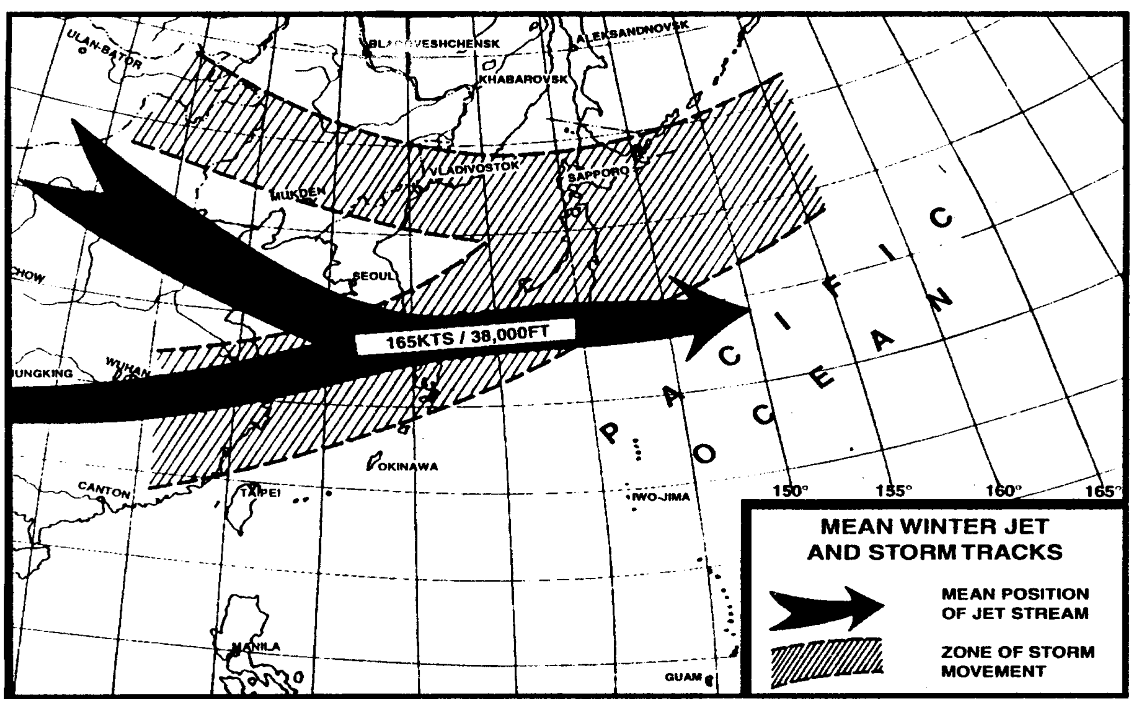

Figure 2-2b. Mean Position of Winter Jet Axis and Zone of Storm Movement

north over the Sea of Japan. Their average speed of movement is 22 knots. Similar to the South Mongolian lows, they do not induce frontal passage in the Okinawa area. Weather conditions throughout central and southern Japan include showers and overcast skies, particularly during the spring and summer months.

(3). Manchurian low. Northernmost of the northern group, these lows never affect Okinawa. Most often occurring during the transition seasons of spring and autumn, they generally track over Sakhalin island into the Sea of Okhotsk.

b. Southern lows. Of significant importance to Okinawa weather, these lows are the primary source of synoptic weather patterns over both Japan and Okinawa. They most commonly develop along the coast of central China near the Yellow and East China Seas. Southern lows generate widespread precipitation, low ceilings, poor visibility, thunderstorms (more common in the spring and summer months), and gusty winds. Cyclogenesis is usually caused by short wave troughs, which are not always identifiable on upper level charts. Formation and speed of movement of these systems are the most difficult parameters to forecast. Once formation has occurred, the cyclonic storm track determines the low type.

If the axis of the Pacific high is located in the vicinity of 25N, and the western edge of the high is just over Okinawa or slightly to the east of the island, weather conditions throughout the Ryukyu Islands are generally good, even when it appears frontal passage is eminent. As frontal systems approach Okinawa when the Pacific high is in this position, they will undergo frontolysis along the axis of dilatation just west of Okinawa. The active portion of the front passes north of the islands, riding over the surface ridge. Resultant weather is scattered cumulus activity and light winds for the island. If, on the other hand, the axis is north of 25N, unfavorable weather conditions occur because of the return circulation on the southwest side of the high. This results in overcast skies and rain showers throughout the Ryukyu Islands. The introduction of a migratory low passing near Okinawa will enhance the already conditionally unstable atmosphere resulting in thunderstorm producing nimbostratus, heavy showers, and gusty surface winds.

(1) Yellow Sea low. Primarily a summer and autumn occurrence, these lows develop near the Yellow Sea in the area between Shanghai and Osan. Getting their strength from the polar front, they track through Korea, over the Sea of Japan, and through Northern Japan. Commonly associated with these lows is the formation of a secondary low system, leading to a "double eye low" or "split low". This secondary development forms south of Kyushu or Shikoku roughly twelve to eighteen hours after the primary low center enters the Yellow Sea. It is this secondary low which influences Okinawa weather, bringing unfavorable conditions. The movement of the primary system is erratic, being completely dependent on upper level features. It is very similar to the Shanghai low in terms of development. A basic distinction between the two is when the low center passes 120E longitude, if it tracks north of 30N, it will be a Yellow Sea low; if it tracks south, it will be a Shanghai low.

(2) Shanghai low. So named for its source region, this type forms near the port city of Shanghai on the eastern coast of China. Shanghai lows usually form in the spring when a shallow Siberian high is centered over southern Siberia and Mongolia and a surface trough with

little or no history takes on an identity and begins to move eastward towards the coast of China. This type of storm tends to be very vigorous, once formed, but may take two to three days to initially develop, depending upon the depth of the surface trough. Important precipitation producers for Japan and the Ryukyu Islands, these lows move east through northeast, normally passing over the southern or eastern coasts of Japan. Their average speed of movement is 20 knots, but they may accelerate to 40 knots, once past 130E.

(3) Taiwan low. Generated as a wave or secondary low along the polar front, its source region is just to the north or northeast of the island of Taiwan. Once developed, it moves east to east-northeast and always passes south of Kyushu. Taiwan lows occur year-round, but are most frequent during the winter and the cooler days of autumn and spring when the polar front lies south of Japan and extends into central China. During the passage of a Taiwan low, aviation weather conditions are usually good in Korea and most of mainland Japan.

5. Migratory Anticyclones and Associated Weather

Most anticyclones follow a general southeastward track, curving to the east-northeast across Japan. This year-round track seasonally varies only slightly. Most high cells, which follow a path significantly different from the general southeastward track, originate north of 70 degrees north. These usually follow an east-southeastward trajectory into the Japan area. Another source region is the Lake Baikal-China area, where most stagnant high cells are located during winter. During winter months, it is not uncommon for a "bubble" high to break off from the Siberian high and move eastward across Japan. These bubble highs are often short-lived as the significantly warmer water of the ocean quickly modifies the dry, cold air of the high.

Okinawa forecasters are interested mainly in those anti-cyclones, which move eastward across the Yellow Sea, East China Sea, or through the Sea of Japan into the Japanese mainland. If the axis of the bubble high is located south of 35N latitude, then weather conditions throughout the Ryukyu Islands are generally good. If, on the other hand, the axis is north of 35N latitude, unfavorable weather conditions occur because of the return circulation on the southwest side of the high. This is a milder version of Taiwan Convergence, which was mentioned earlier, and results in overcast skies and rain showers throughout the Ryukyu Islands.

6. Tropical Cyclones

Tropical cyclones occur in the western Pacific during all months of the year. Likewise, Okinawa has been directly affected by a tropical cyclone, at one time or another, during every month of the year. The period from June through the end of November is the period of greatest probability of tropical cyclone formation and incidence near Okinawa, and hence is known as the "typhoon season". The peak months in terms of number of tropical cyclones are August and September, but the threat is still high during October and November. The primary source area for tropical cyclone formation lies to the south and east of Guam. However, formation within 300 NM of Okinawa, south or southeast of the island, is not uncommon. For this reason, the forecaster must monitor every large area of deep convection carefully and be constantly aware of the possibility of tropical cyclone formation. Once formed, most tropical cyclones assume a west to northwest track. Early in the season, when the mid-latitude westerlies are weak and remain further north, recurvature becomes the rule rather than the exception. Tropical cyclones, therefore, usually track around the periphery of the subtropical high in the vicinity of Okinawa.

The Regional Commander, (Commander, 18th Wing, Kadena Air Base), also referred to as the "Single Service Coordinator (SSC)", is responsible for setting Tropical Cyclone Condition Of Readiness (TCCOR) for Okinawa. The General makes these decisions based on recommendations provided by the Operations Weather Officer, 18OSS/OSW (Air Force Weather Squadron). The Navy Installation Commander, Commander, Fleet Activities Okinawa (CFAO), is responsible for implementing TCCOR preparations within all U.S. Navy installations on Okinawa. When the SSC sets TCCOR, the setting may not accommodate the Navy's requirement to support maritime vessels. CFAO has to consider the much slower process of getting ships underway and to a safe distance, which takes 24 hours or more, depending on the material condition of the ship and its ability to handle high winds and seas. Coupled with that, once outside the harbor, the ship has limited headings to assume, regardless of the direction the tropical cyclone is headed. When evading a tropical cyclone while underway, there is no substitute for distance. The closer the cyclone, the fewer options the ship's Commander will have. Therefore, CFAO may be required to implement the preparations of a higher TCCOR setting to best prepare the Navy's customer with regard to safety and readiness. In doing this, CFAO is NOT setting a higher TCCOR, but is rather going through the motions of implementing the condition of readiness required of a higher TCCOR. It is the responsibility of NAVPACMETOC DET Kadena to coordinate with 18OSS/OSW and make TCCOR recommendations to CFAO based on the Joint Typhoon Warning Center's storm track and disposition of maritime assets.

7. Seasonal Systems and Associated Weather

In general, Okinawa experiences two primary seasons each year; summer and winter. Mild winters and very warm summers are the norm, and humidity is high year-round. The weather pattern of any given season depends upon the relative strength of the semi-permanent Pacific and Siberian high pressure cells as they are divided by the polar front. In the summer, the Pacific high dominates the region, creating a southerly flow pattern, which brings the warm and humid maritime tropical (mT) air mass over Okinawa. During the winter, the region is dominated by the Siberian high, creating a northerly flow pattern, which brings modified continental polar (cP) air over Okinawa. Spring and autumn are transition seasons, variable in length and weather conditions from year to year. During these seasons, the importance of upper air features in synoptic forecasting far outweighs the pattern and distribution of surface weather features.

a. Winter. During winter, the mean position of the polar front is located south of Okinawa and the weather is dominated by the semi-permanent Siberian high. From January to March, the daily weather follows a cyclic pattern, which lasts from three to eight days. A significant trough or front develops in northern China as a result of an outbreak of the Siberian high. It moves rapidly southeastward, aligning itself with the polar front and beginning to intensify. As the front develops, Okinawa enjoys scattered low and high cloudiness and unrestricted visibility. In the area of the front, surface weather patterns include gusty winds, towering cumulus, heavy rain showers and occasional thunderstorms. The front begins to move over the East China Sea, usually at speeds of up to 20 knots. Surface winds in Okinawa prior to the front are light and variable.

It is important to note the position of the Pacific high's axis just prior to frontal passage. As mentioned earlier, it could mean the difference between frontolysis or genesis at the axis of dilatation, which could mean fair skies and light wind or inclement weather over Okinawa.

If the front makes it to Okinawa, just before it arrives, winds may shift to the southwest or west. A wind shift to the northwest or north, often with wind speeds of 30 to 40 knots, occurs with passage of the front and serves as the best indicator of frontal passage. In general, light precipitation begins just prior to frontal passage and ends within six hours, depending on the speed of the frontal movement. During this period, ceilings may decrease to 500 feet or less, with accompanying limited visibility. Arrival of the actual cold front may be hard to detect because of the presence of a "false front." Brief, light rain showers may be present around the time of the initial wind shift, giving strong radar echoes, which resemble a front.

After the front passes, winds become light and northerly. Four to six hours later, heavy showers and sustained strong winds with accompanying gusts will occur.

Subsequent to the passage of the front, weather patterns consist of one to three days of broken to overcast stratocumulus clouds with bases around 2,000 feet and tops at 6,000 feet. Above this layer, the sky is cloud-free. This low cloud layer persists until the strong northerly winds, generally at speed between 25 and 35 knots, decrease in intensity and shift to the northeast. Clearing then takes place, with the return of low scattered cumulus and high broken cirrus layers. At this point, the cycle begins to repeat itself.

b. Spring. A transition period known as the rainy season, is the result of the Transitional Convergence Zone. The length of the season, as well as the amount and intensity of rainfall during the season varies greatly from year to year. Usually the amount of rainfall during this season is not much greater than that of summer, but the occurrence of continuous periods of precipitation is much more frequent. As the polar front begins to migrate northward, short waves develop into unstable waves along the frontal zone. Cyclogenesis often takes place off the Taiwan coast or in the Shanghai area. Light rain and drizzle with occasionally heavy showers and thunderstorms persist at Kadena for periods of six to thirty-six hours as the resultant system moves through the area. Low layers of stratus and cumulus fractus, with occasional frontal fog, accompany the precipitation.

Weather during this period can be most difficult to forecast. During June, the rainy season is at its height. Latitudinal fluctuations of the polar front across Okinawa bring surface cyclonic systems through the area, generating heavy, continuous rain as frontal passage occurs. By mid-June, the polar front has repositioned itself to the north for the remainder of the season and the low-level wind shear that resulted in the Transitional Convergence Zone has diminished as the southwest monsoon becomes well established.

c. Summer. The tropical cyclone or "typhoon" season for Okinawa begins in late May / early June and continues through November, reaching its peak in August and September. Weather phenomena resulting from typical tropical cyclone passage begin with light to moderate shower activity as the storm approaches. Towering cumulus and isolated cumulonimbus are common, as is a shield of cirrostratus. Nearer the center, moderate to heavy intermittent rain and heavy showers occur. Ceilings vary from 200 to 2000 feet, and visibility varies from one-half to five nautical miles. Near the eye of the storm, rain and blowing spray are mixed by the high, gusty winds. Similar weather continues on the backside of the storm, usually with less intensity. Clearing can begin very soon after passage, with winds gradually diminishing.

d. Autumn. In late September, the polar front returns to the local area. During the autumn months, it moves rapidly southward, in contrast to its slow and erratic northward movement during the spring. As a result, the Transitional Convergence Zone lasts only two to three weeks. Frontal passages are usually brief, with four to six hours of light rain or drizzle. Heavy shower or thunderstorm activity is rare. Skies clear rapidly after frontal passage, leaving scattered low and middle cloudiness, with thin broken to overcast cirrus. The polar front, when south of Okinawa is weak and usually does not possess well-defined frontal characteristics. Okinawa is dominated by a modified cP air mass, which brings the best flying weather of the year during the early part of the season. Tropical cyclones occasionally threaten Okinawa until December. Any extended period of low ceilings and visibility is usually associated with a tropical system. Afternoon and evening towering cumulus may still form, but occurrences are isolated. Precipitation is light. This time of the year may be termed the "dry" season, aside from the infrequent tropical cyclone passage, which increases mean monthly precipitation statistics. Surface winds are predominantly northerly, and the mean wind is at its annual maximum. Autumn-type weather continues until the Siberian high intensifies to the point where cold outbreaks become a regular pattern, usually during December or January.

8. <u>Local Effects on Okinawa</u>

a. Temperature

(1) Due to the modifying effect of the warm Kuroshio current, temperature variation is not a problem to the forecaster. During winter, mean minimum temperatures are in the mid-fifties, with a few days of extreme low temperatures in the upper forties. In the summer, mean maximum temperatures are in the upper eighties, with extreme highs in the high nineties. Diurnal effect is approximately a seven to ten degree (F) change throughout the entire year.

(2) Exceptions to the diurnal variation will occur with the passage of a tropical cyclone, during which the daily extremes vary less than three degrees. Spring precipitation of a continual nature will hold the diurnal variation to approximately five degrees.

(3) During summer temperatures may drop as much as eight degrees during a heavy afternoon shower. This temperature fall is temporary, lasting little longer than the shower.

(4) Fronts that pass through Kadena generally result in little direct temperature change with only a two to four degree difference. On the day following frontal passage, temperatures conform more closely to the characteristics of the new dominant air mass.

b. Humidity. Humidity is high at Kadena throughout the year, with relative humidity rarely dropping below 70 percent. During June the humidity reaches its yearly maximum, due to the influx of warm moist tropical air. The annual mean relative humidity is 80 percent.

c. Surface winds

(1) Surface winds at Kadena AB are of a monsoonal nature, northerly in winter, southerly in summer. The spring and autumn seasons experience transitional winds. The lightest mean winds occur during September, while the strongest mean winds are experienced in November.

(2) During winter, surface winds sometimes gust to 30 knots or higher from the northwest through north after a frontal passage. Strong northwesterly winds also create turbulence in the lower layers over the runway. In summer, tightening of the pressure gradient caused by the building Pacific high occasionally causes moderately gusty winds, approximately 20-25 knots, from the southeast.

(3) Winds associated with a typhoon or tropical storm follow the normal distribution pattern. The anemometer at Kadena AB is located in the center of the field. Wind reports from Naha, with the wind instruments near the shore, and the Japanese Meteorological Agency, with the anemometer on a hill, will often reflect winds from five to twenty knots higher than those reported at Kadena during a typhoon. MCAS Futenma, located on a hill approximately 4 1/2 miles south of Kadena AB, has their anemometer positioned 270 feet above MSL. MCAS Futenma will usually report the strongest winds on Okinawa during typhoons.

d. Cloudiness

(1) Stratocumulus. Following the passage of a strong cold front or squall line from the northwest, Kadena AB experiences an extended period, 12 to 72 hours, of broken to overcast stratocumulus. The base of this layer averages about 2000 feet, with a top at approximately 6000 feet. The sky is usually completely clear above this layer. It will persist as long as the wind is from the northwest through north-northeast, gusting to 25 knots or higher. Occasional light rain or drizzle will occur but will not restrict visibility to below five miles. This layer will persist after a frontal passage until the wind shifts direction to northeasterly and loses speed.

(2) Stratus. When surface winds at Kadena AB are southerly, stratus may form south of Kadena and be advected over the base itself. This layer usually arrives one to two hours after sunrise and may persist for three hours. The base of this layer is at or below 1000 feet, and is normally less than a thousand feet thick. At times this stratus burns off as a result of normal

morning heating; the length of time for dissipation is determined by the amount of higher cloud cover. This stratus most commonly occurs during late spring and early summer.

(3) Middle cloudiness. A broken layer of altocumulus or altostratus may form during an otherwise clear night and persist until mid-morning. This layer is usually thin, less than two thousand feet thick. It varies in height from 8000 feet to 16,000 feet, and it occurs predominantly during the summer and autumn. The best indicator of its formation is a thin, moist layer on the 1200Z sounding, with very dry air above it. An inversion may appear at this level, but is not necessary for mid-cloud formation.

(4) Towering cumulus, cumulonimbus, and thunderstorms. There are two types of convective clouds that affect Kadena AB; Air mass and line. During the summer, large convective clouds are virtually a daily occurrence over the island. These are triggered by the heating effect of the island and are most common over the steep northern hills of the island. Often these large towering cumulus or cumulonimbus clouds reach 30,000 feet and occasionally exceed 50,000 feet. True thunderstorms are infrequent over the island itself, although isolated anvil clouds may often be observed along the horizon. Except for their size, these clouds rarely exhibit typical thunderstorm characteristics. There is no anvil cloud, no lightning, no hail or strong down rush of cold air. There is heavy rain in the core of the storm and should be considered as hazardous as a typical thunderstorm. Visual and radar checks are the primary methods for forecasting these clouds.

(5) Funnel clouds. These may be observed at Kadena during the autumn, particularly in October. Funnel clouds, by their very nature, are rare; however, Kadena AB appears to have experienced more than a normal number of sightings with a few touching down on land resulting in significant damage. These clouds develop from towering cumulus, which have tops from 15,000 to 20,000 feet.

e. Precipitation

(1) Distribution of the average annual rainfall is shown in chapter III, Monthly Climatological Summaries. There are two marked periods of maximum rainfall, both occurring near or during the summer. The May-June peak indicates the extent of the late spring rainy season, while the August maximum corresponds to the peak month of tropical cyclone activity on Okinawa. It should be noted that during late summer and autumn, almost half of all island precipitation is generated by tropical cyclones.

(2) Rain and drizzle. During warm frontal passages, rain is light but persistent. As cold fronts or squall lines pass, precipitation is primarily in the form of heavy showers, accompanied by short (two to six hour) periods of light, intermittent rain or drizzle. This intermittent light rain does not normally restrict visibility to below three miles, but heavy continual rain or drizzle may cause visibility to be reduced as low as one mile for up to twelve hours. Most precipitation from tropical cyclones is in the form of moderate to heavy intermittent rain; precipitation totals on Kadena vary greatly depending upon the size of the storm, its CPA, and the maturity of the storm as it approaches Okinawa.

(3) Showers. Summer-time showers are a common occurrence and may restrict visibility to as low as two miles at Kadena AB for very short periods of time. If a large towering cumulus or cumulonimbus cloud is over the field, its showery precipitation may force visibility down as low as 1/4 mile for as long as 20 minutes. In heavy line showers, visibility may remain between one and three miles for as long as several hours.

f. Fog

(1) Virtually all the fog that occurs at Kadena is co-existent with precipitation. When fog occurs with light, continual rain or drizzle, visibility may remain as low as one to three miles for periods up to twelve hours or more. This occurrence is most likely with a stationary or warm front near Kadena, but it may occur during any period of extended precipitation.

(2) Radiation ground fog is sometimes observed during early mornings in spring and summer. This fog lies in the valley along the northeast end of the field or in the small hills to the northeast of the base. Visibility is rarely reduced to below seven miles from radiation fog.

(3) There have been isolated instances when Kadena AB was affected by a combination advection and radiation fog. This occurred when a stratus bank remained over the ocean during the day, moved over the base during the evening, and persisted until morning. Around sunset, winds were light and southerly. Visibility in the fog ranged from zero to two miles. This was a very rare occurrence and should not be forecast unless there is direct evidence of its existence, such as the presence of a stratus bank over the water during the day.

g. Haze, Dust, and Smoke

(1) Haze. Haze may affect visibility at Kadena. It is normally at its worst during mid-morning or late afternoon on summer days. This summer haze is predominantly composed of water and salt particles and should not be confused with dust. Visibility is not restricted below five miles.

(2) Dust. Common during winter and spring, dust may lower prevailing visibility down to three miles. Visibility is lowest during the day and improves at night, when the dust appears to settle. Quite often the observer will mistake the dust for haze. The source region for the dust is the Gobi Desert, located throughout southern Mongolia. Occasionally during the winter, a deep low pressure cell, extending through the 500 millibar level, is observed over the Gobi region. This low coupled with a strong outbreak of cold air from the Siberian high and the influence of the polar jet, carries the dust to the Ryukyu Islands. The dust often affects visibility to a height of 20,000 feet over Okinawa, and may persist from one to three days. An analysis of the mid-atmospheric wind flow (7,000 to 18,000 feet), a verification of visibility restrictions at stations 47927, 47918 and 47909 and awareness of dust storms prevalent throughout the Gobi Desert will aid in forecasting dust occurrences at Kadena.

(3) Smoke. Occasionally, a southeasterly breeze may blow smoke over Kadena

AB. It originates from the city of Koza, and is most noticeable on a still summer evening. In the early morning, smoke trails, or thin smoke layers, may then be observed over the village of Kadena Circle and / or the northern quadrant of the field. In both cases, visibility will remain at seven miles or greater.

B. Operational Considerations for Kadena Forecasters

Aviation weather conditions at Kadena compare favorably with most good weather bases in the world. However, one important operational feature must be taken into consideration - Location. In supporting short-range fighter aircraft (with a limited fuel supply), alternate landing fields are limited. Kadena AB, MCAS Futenma, and Naha International are the only airfields within 500 NM that can support fighter aircraft. Therefore, local flying must be restricted for various weather minima that would present few or no problems if there were alternate airfields within 100 nautical miles. In actual day-to-day operations, if ceilings and / or visibility drop below 1500 feet / 5 miles, it becomes marginal flying weather. When conditions fall below, or are forecast to fall below, 1000 feet / 3 miles, flying virtually ceases in the local area (for fighter / short-range aircraft). Surface crosswinds above 14 knots may also limit local training flights. Evacuation of aircraft during the approach of a typhoon will suspend all local flying until the threat has diminished.

Operationally, many of the climatological statistics do not reflect an accurate picture of airfield weather, such as a summer shower that may cover half of the runway but not restrict prevailing visibility or even have enough sky coverage to be called a ceiling. Factors such as these are a real day-to-day hazard to aircraft operations.

1. Ceiling and Visibility. Meteorological watch advisories are issued by the 18th Operations Support Squadron when ceiling and / or visibility are observed or forecast to be below 1500 feet / 3 miles.

2. Turbulence. Convective activity causes light turbulence during all seasons over Okinawa. Gusty low-level winds during the winter months can cause light to moderate turbulence in the vicinity of Kadena. Wind shear is at a maximum on the north side of the jet. However, it can approach maximum intensity on the south side as well. South side shear can be as strong as 100 knots per 300 NM, with clear air turbulence occurring with moderately high values. Turbulence induced by the jet stream is most prevalent between 400 and 300 MB, with intensity proportional to the strength of the jet. Shear values of up to 50 knots per 1000 feet can occur at times, particularly in the vicinity of the polar front.

C. Oceanographic Climatology

The waters surrounding Okinawa contain some of the world's most complex bathymetry. Volcanic islands are adjacent to deep trenches, while seamounts, guyots, and submarine ridges abound. The warm Kuroshio current carries subtropical water masses into colder Japanese waters, creating numerous frontal zones and transient eddies. Thermal water mass structure, as well as the sea surface temperature gradient, reflect this movement and provide information on oceanic frontal locations. Major Bathymetric Features can be seen in Figure 2-3.

1. Water Basins

a. Yellow Sea. Located between the Korean peninsula and the Chinese mainland, the Yellow Sea is a semi-enclosed basin. It extends from the Yangtze River Delta at its southern boundary to the island of Cheju Do at its open, northeast edge. The basin is a typical inland-sea, rather shallow and flat. There are no depths greater than 100 meters, and the majority of the basin is less than 50 meters deep. Its bottom is primarily composed of silt and clay, with an extended area of sand bordering the Korean coast.

b. East China Sea. Bounded on the west by the Chinese mainland and Yellow Sea and on the east by the Ryukyu Islands, the East China Sea extends from the Tsushima Strait to Taiwan. Another typical inland-sea, it is generally flat and featureless with an average depth of 100 meters. However, along the sea's eastern edge lies the Okinawa Trench, a major ocean trench with an average depth of 2500 meters. Sand, silt, and clay, all characteristic of the Great Yangtze Sandbank of which this basin is a part, cover the basin bottom.

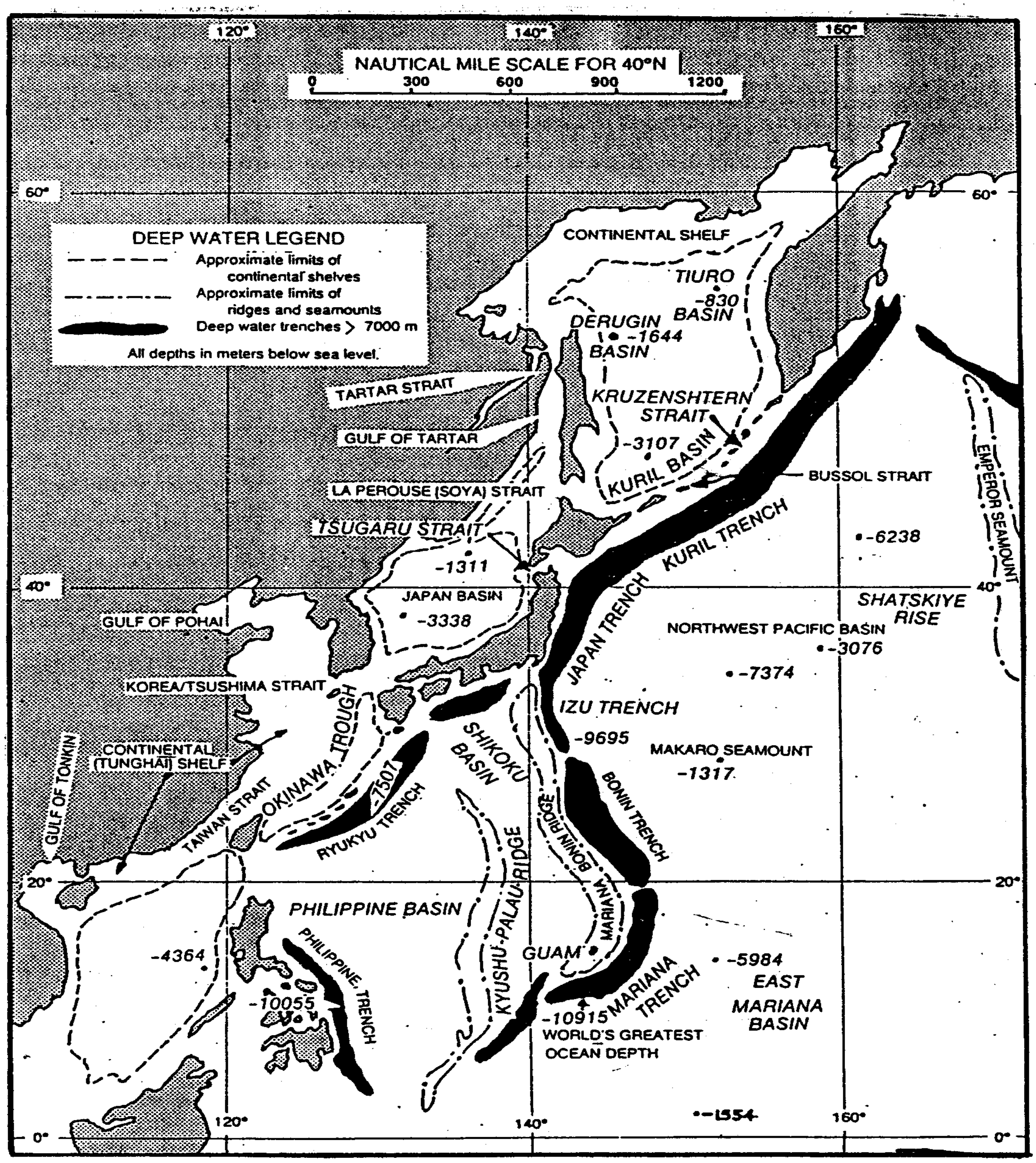

Figure 2-3. Major Bathymetric Features

c. Sea of Japan. A teardrop-shaped basin lying between Korea, China, and the main Japanese islands, the Sea of Japan extends between Sakhalin and the Tsushima Strait. Also considered an inland-sea, the basin can be divided into three regions. To the north, the bathymetry is dominated by the Japan Abyssal Sea Plain, which possesses an average depth of 3500 meters. In the south, the basin is divided in two by the Yamato Ridge, oriented northeast to southwest with depths ranging from approximately 300 meters to over 1000 meters. The entire basin bottom is composed almost exclusively of silt and clay, with areas of sand and gravel scattered throughout.

d. Philippine Sea. To the east of the Philippine archipelago and extending eastward to the great Mariana Trench lies the Philippine Sea. Its north-south extent lies between the southern Ryukyu Islands and the Caroline and Palm Island groups. The most prominent bathymetric feature of the basin is the Philippine Trench, which extends along the eastern edge of the Philippine Islands and contains depths in excess of 10,000 meters. The rest of the sea basin contains average depths of approximately 4,000 to 5,000 meters. Other bathymetric features of this ocean basin include numerous atolls, seamounts, guyots, and ridges. Bottom sediment is principally clay.

e. Northwest Pacific. Of particular interest to the Kadena forecaster is that portion of the Pacific Ocean that lies to the east of Japan from Hokkaido to the southern Ryukyu Islands. Bathymetrically part of the same Pacific Ocean basin, the region possesses the most complex bathymetry on earth. Trenches include the Mariana Trench, Bonin Trench, Japanese Trench, and Ryukyu Trench. All of which contain depths in excess of 11,000 meters. The Emperor Seamount chain contains many of the numerous seamounts that dot the basin floor, while guyots and undersea ridges abound. Atolls and island chains are scattered throughout the region. The average depth of this basin is between 5,000 and 6,000 meters. Bottom sediment ranges from sand and gravel near the numerous island chains to silt and clay in open ocean areas.

2. Straits and Channels

a. Tsushima Strait. Lying between the Korean peninsula and the main Japanese islands of Kyushu and Honshu, the Tsushima Strait forms the primary entrance and exit point for the Sea of Japan. It is relatively shallow, as depths are primarily less than 120 meters. Numerous islands of varying size lie both within the Strait and at either end. The bottom is composed of sand and gravel carried in by the Tsushima Current.

b. Bashi Channel. Running between the southern tip of Taiwan and the northern Luzon coast, this strategic passageway handles most ship traffic between the Pacific and Indian Oceans. Unlike the Tsushima Strait, the Bashi Channel is relatively wide and deep. It averages 2,500 to 3,000 meters in depth, and possesses bottom sediment of sand, silt, and clay.

3. Major Ocean Currents

The northwest Pacific Ocean has perhaps the most complex and variable system of ocean currents in the world. It is part of the North Pacific Subtropical Gyre, a system of currents, which dominate the flow in the north Pacific. At tropical latitudes, the gyre contains the North Equatorial Current, better known as the Kuroshio Current. This current moves westward from the central Pacific, curves to the northeast of the main Philippine island of Luzon, and then continues its northward flow toward the main Japanese islands. As it nears the island of Kyushu, it splits into three branches, two primary and one secondary. The larger of the two primary branches, known as the Kuroshio Extension, flows along the eastern coast of Japan. The other primary branch enters the Sea of Japan through the Tsushima Strait, forming the Tsushima Current. The secondary branch flows northwest to form the Yellow Sea basin current. These warm currents, together with their cold, return-flow counterparts, are a principal cause of the complexity of the ocean thermal structure in the waters surrounding Okinawa. Currents and Associated Fronts can be seen in Figure 2-4a. Prevailing Surface Current direction and speed can be seen in Figure 2-4b.

a. Kuroshio Current / Kuroshio Extension. Analogous to the Gulf Stream in the north Atlantic, the Kuroshio Current is the northeastward flowing, warm western boundary current of the north Pacific. The name "Kuroshio" means "black stream" and refers to the dark cobalt blue color of the current waters. This color is an indication of the absence of marine life within the swift-moving current. The primary current, between 20N and 30N latitude, is roughly 150 to 180 NM wide; near 30N, it decreases to 80-100 NM in width as it branches into the Kuroshio Extension. Speeds within the current system are seasonal and reflect the strength of the monsoonal flow. During the spring and summer, primary current speeds average approximately 1.5 to 2.0 knots, while speeds in the Extension average 2.5 to 3.5 knots. Lower speeds prevail in the winter; the main current moves at approximately 1.0 to 1.5 knots, while the waters of the Extension move at 2.0 to 2.5 knots. The massive volume of warm water transported by this current system into the western Pacific region exerts a strong influence upon regional weather. Okinawa, for example, experiences neither extremely cold nor extremely warm temperatures as a direct result of the Kuroshio's moderating influence.

b. Tsushima Current. Branching northwestward from the Kuroshio current just south of Kyushu is the Tsushima Current. This current enters the Sea of Japan through the Tsushima Strait, dominating the entire Strait, and continues its northward flow to wash the western coast of Hokkaido. Because of its origin in the Kuroshio System, this current is also deep, swift, and warm. It is the primary reason for the year-round ice-free character of the southern Sea of Japan. Speeds of the current, as it moves through the Tsushima Strait, vary between 1.0 to 1.5 knots during the spring and summer to 0.5 to 1.0 knots during the winter. In the relatively open waters of the Sea of Japan, the current speeds decrease to 0.8 to 1.5 knots during the spring and summer and 0.4 to 0.6 knots during the winter.

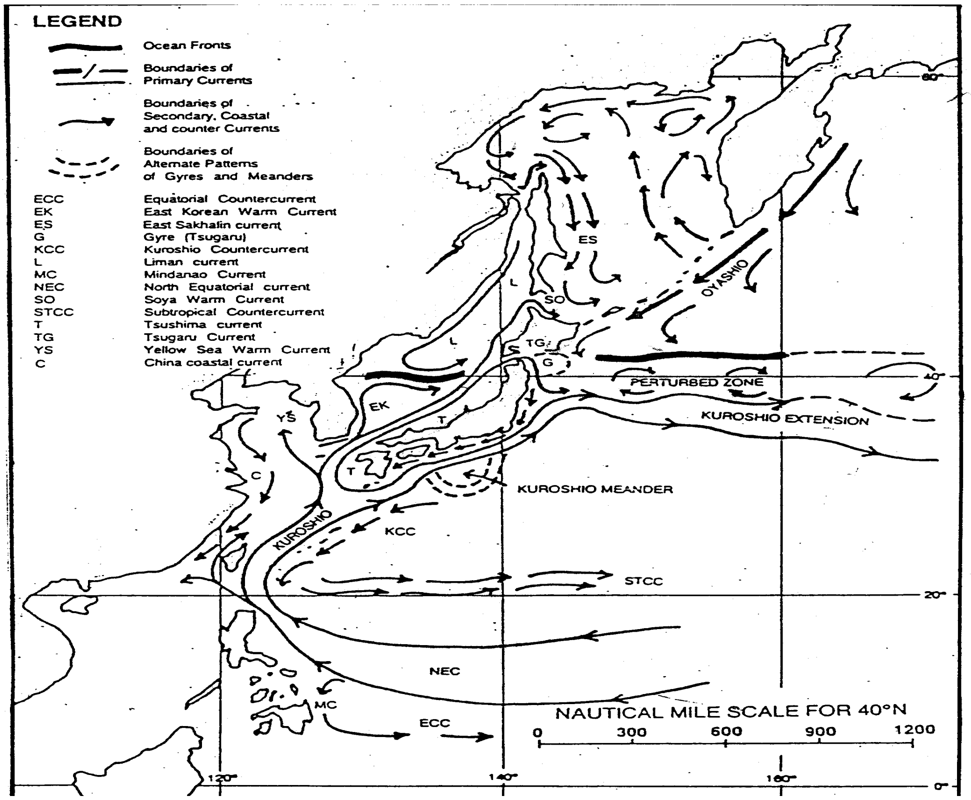

Figure 2-4a. Ocean Currents and Fronts

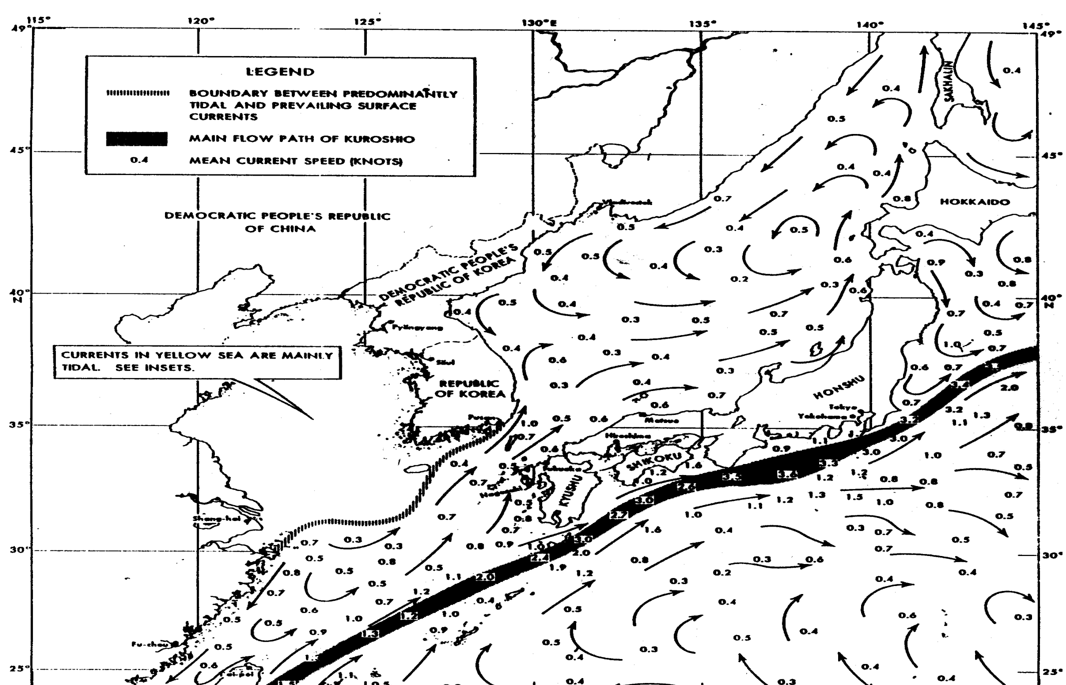

Figure 2-4b. Prevailing Surface Currents

c. Yellow Sea Current. During the southwest monsoon season, primarily summer, this secondary branch of the Kuroshio system forms and flows into the Yellow Sea basin. It exerts only a minimal influence on the Yellow Sea, as the primary water circulation within the basin is determined by tidal flow. However, the formation and presence of this current help to generate a cold counter-current which flows southward during the northwest monsoon season, late fall, winter, and early spring. This colder water is a major cause of fog formation in the Yellow Sea.

d. Liman Current. A cold northeasterly current located along the western Sea of Japan. It is strongest during the winter, or northeast monsoon season, when it carries extremely cold water to the southwest at speeds of up to 1.0 knot. Advection fog, generated by the passage of warmer air masses over the much colder water, is common in the current's area of influence. During the summer, when warmer waters dominate the Sea of Japan, current speeds drop to approximately 0.5 knots.

e. Kuroshio Counter-current. A cooler northeasterly current, this counter-current is the return-flow counterpart of the main Kuroshio Current. It is a shallow, fairly diffuse current that flows southward along the southern and eastern boundaries of the Kuroshio and extends to the south of Okinawa. It is highly variable in both speed and area. During the winter (northeast monsoon), it reaches maximum strength; heating and surface mixing during the spring and summer months cause it to lose its identity and make it extremely difficult to locate.

4. Ocean Front Areas

Roughly analogous to atmospheric frontal systems, ocean fronts exist between water masses of dissimilar character. While thermal differences primarily denote frontal areas, salinity and sediment differences also create frontal zones. Frontal zones can be generally located from knowledge of seasonal ocean currents. The undulation of the specific narrow frontal zone is of special interest to the naval forecaster. While movement of oceanic water masses and their associated frontal zones takes place over a period of days, not hours, it can be dramatic and complex. Deep eddies, coupled with surface and near-surface thermal gradients, can significantly change the acoustic propagation characteristics of the ocean over a period of just a few days. Knowledge of the exact location of these frontal zones is of tactical significance to operational forces.

a. North Wall (cold side) of the Kuroshio Current. Located along the northern edge of the Kuroshio Extension, this frontal zone lies between the main body of the Extension and the colder north Pacific waters from the island of Kyushu to approximately 155 degrees east longitude. A zone of intense surface mixing, the surface front may well be strongly displaced from the subsurface front. Together, these two characteristics cause a significant reduction in the layer depth as one moves perpendicular to the front. Although the location of the North Wall is generally stationary, meanders and turns in the flow of the current cause its exact location to change almost weekly. The surface front is most easily located through identification of the horizontal thermal gradient on a sea surface temperature (SST) analysis or from infrared (IR) satellite imagery. This front is strongest during the winter, when the contrast between the warm

Kuroshio current and the surrounding cold ocean water is greatest.

b. Yellow Sea Front. Forming west of the main body of the Kuroshio Current, this front extends from the southern coast of Korea to the Chinese coast near Shanghai. While the general location of this front is also semi-permanent, intrusions of warm water into the Yellow Sea or intrusions of cold water out of that body distort the frontal boundary. At its strongest during the winter season, tongues of cold water originating in the Yellow Sea during the northeast monsoon can well move the southern frontal boundary through the Taiwan Strait and into the vicinity of Hong Kong.

c. Sea of Japan Front. This front separates the flow of the East Korean Warm Current and the Tsushima (warm) Current from that of the Liman (cold) Current, this front generally extends from the southeast coast of North Korea to the Japanese island of Hokkaido. Because of the current convergence, this frontal zone is characterized by intense mixing. Frequent intrusions of cold water from the Liman Current cause the frontal position to be extremely variable.

d. Okinawa Front. So named because of its location, this front is formed by the Kuroshio Countercurrent. Its position is highly variable and has been known to shift hundreds of miles in a matter of weeks, responding to changes in the Counter-current flow. This front tends to be seasonal and achieves its maximum strength in the winter.

e. Warm core / cold core eddies. Formed by meanders in the main flow of the Kuroshio Extension, these eddies break away from the current and move into the nearby water basins. These eddies tend to be long-lived and represent a thermal difference of several degrees Celsius from the surrounding waters. Tactically significant information can be gained from knowledge of their location, both on the surface and at depth.

5. <u>Sea Surface Temperatures (SST)</u>

Dependent upon the seasonal insolation cycle, sea surface temperatures exhibit a time lag of several months due to the thermal properties of sea water. While maximum insolation occurs during July and August, the maximum water temperatures occur during August and September. Sea surface temperatures are also very much dependent upon current movement and strength. As a rule, the isotherms parallel the flow of the warm currents; during the summer, the reduced thermal contrast washes out the frontal effects of the warm currents.

Perhaps the greatest SST variability in the area of interest occurs in the Yellow Sea. During late summer and early autumn, SSTs reach 80-82 F / 27-28 C, while winter temperatures average 39-43 F / 4-6 C. It is not uncommon for sea ice to form in the extreme northern Yellow Sea during mid to late winter.

Sea of Japan SSTs do not have a large range and remain fairly cool throughout all but the hottest months. In the northern part, temperatures range from 64-68 F / 18-20 C in September to 36-39 F / 2-4 C in February. To the south, SSTs range from 72-75 F / 22-24 C in September to 46-50 F/ 8-10 C in February.

Temperatures in the East China Sea and to the east of the Ryukyu's vary between 75-79 F / 24-26 C during the late summer and early autumn to 61-68 F / 16-20 C during the late winter.

In the Philippine Sea, the annual temperature variation is rather small. Temperatures range from 82-86 F/ 28-30 C during early autumn to 79-82 F / 26-28 C during late winter.

6. <u>Mixed Layer Depth (MLD)</u>

Like the SST, this changes significantly throughout the area of interest in response to the seasonal insolation cycle. It can also vary on a monthly basis in response to temperature advection and subsequent mixing of the water column. During the winter season, the MLD is most pronounced. Layer depths run between 100-200 feet in the Yellow and East China Sea, between 300 and 400 feet in the Tsushima Strait, around 100 feet in the southern Sea of Japan, between 300 and 500 feet in the Okinawa and Kuroshio Extension area, and between 100 and 200 feet in and east of the Philippine Sea. An interesting observation is that the deeper layer depths tend to follow the axis of the main currents in the area. During the spring, the MLD begins to shoal and by summer, it is less than 100 feet in depth throughout the entire area or is nonexistent. The mixed layer starts to deepen again in the autumn, and usually by November, layer depths throughout the East China Sea, Okinawa area and through the Kuroshio Extension return to between 100 and 200 feet. The Yellow Sea and the Sea of Japan, at this time, are just beginning to develop a mixed layer, with its depth remaining less than 100 feet.

7. <u>Sea State</u>

Wave heights average 3-6 feet throughout the entire WESTPAC area of interest. However, seasonal height averages fluctuate across the area in response to general atmospheric trends. Frequent passage of extratropical cyclonic systems, during the winter months, with their attendant higher wind speeds, generate wave heights in excess of 12 feet for areas north of Okinawa. Between Okinawa and Taiwan, wintertime frontal systems are generally slow moving, stationary, or fairly weak and fail to generate much sea surface turbulence. During the summer months, the situation is reversed. The areas south of Okinawa receive wind and swell waves from almost all tropical cyclones generated in the western Pacific. The state of the sea in an area is directly proportional to the strength of the tropical cyclone system and proximity of the system to the area of interest. Areas north of Okinawa receive the effects of tropical cyclone-generated wind and swell waves only as the individual system moves through the area.

8. <u>Buckner Bay</u>

a. Wave Action. The maximum wave height that can be expected with typhoon strength winds (>64 knots) are:

	White Beach	Mid-Bay
Winds generally from the north (tropical cyclones pass east of		

Buckner Bay)	4 feet	6 feet
Winds generally from the north (tropical cyclones pass west of Buckner Bay)	20 feet	16 feet

Maximum wave heights up to 20 feet can be expected from a typhoon passing within 20 nautical miles to the west of Buckner Bay. The resulting southerly winds generate waves that are virtually unopposed before reaching White Beach, although the coral reefs and islands surrounding Buckner Bay offer some resistance.

b. Storm Surge and Tides. For storms approaching Okinawa from the south, a storm surge will have maximum effect in bays which open to the south and east and if the harbor is located in the dangerous semicircle. According to statistical information by the U.S. Naval Oceanographic Office (1964), a maximum storm surge of 7.8 feet can be expected. The maximum tide at Buckner Bay is 7.0 feet.

c. Combined Effects. When all variables are combined, a “worst case” scenario can be ascertained. For example, maximum storm surge at high tide in Buckner Bay would result in a rise of 14 to 15 feet above the mean water line. With the addition of the incoming swell / breaker (16 to 20 feet) total height above mean water line is 23-27 feet. The same scenario for White Beach would result in a total rise of 18-21 feet above the mean water line. Even though this is a worst case scenario for Buckner Bay, damage to White Beach facilities is quite common due to the close proximity of the low-lying buildings to the beach.

d. Buckner Bay as a haven. Buckner Bay is not considered to be a haven during typhoon conditions. The lack of extensive protection from wind due to the relatively low topography of the surrounding landmass and the exposure of ships to wind and seas with any easterly component severely limits Buckner Bay as a storm refuge. It is recommended all U.S. Navy ships that are capable, take action to evade at sea when typhoon conditions threaten Buckner Bay, Okinawa.

9. Naha Harbor

a. Wave Action. Wave action in Naha Harbor is severe enough to halt all traffic with the onset of 25 knots or greater winds. Although ships have been moved in winds up to 50 knots during emergency conditions, wave action in the harbor can be destructive enough to necessitate clearing the port of all vessels when winds of 50 knots or greater are expected within 24 hours. The maximum wave heights that can be expected with typhoon strength winds (>64 knots) in Naha Harbor are:

	Main Inner Harbor	Main Outer Harbor

Winds generally from the north (tropical cyclone pass east of Naha)	8 feet	15 feet
Winds generally from the south (tropical cyclone pass west of Naha)	4 feet	12 feet

b. Storm Surge and Tides. During periods of moderate to strong northwesterly winds, a surge effect of 2-3 feet is evident in the main inner harbor. When this surge effect coincides with a high tide, an abnormal rise in water level occurs.

c. Naha as a haven. Naha Harbor is a poor haven during typhoon conditions. The key factors in reaching this conclusion were:

(1) Lack of sheltered berths.

(2) The threat of other vessels adrift in a confined harbor.

(3) High sea states within the harbor area with winds of 25 knots or greater.

(4) Poor anchor holding action at the harbor bottom.

d. It is recommended all U.S. Navy ships capable, take action to evade at sea when typhoon conditions threaten Naha, Okinawa.

10. <u>Tsunamis</u>

Previously mentioned in the physical description of the Ryukyu Islands, volcanic activity and earthquakes are a common occurrence within and around the island chain. A Tsunami is a seismic sea wave produced by such undersea phenomena.

Tsunami waves have an extremely long wavelength and travel at speeds of 400-500 miles per hour. The speed is dependent on the depth of the water it is transiting through. They are not observable until they begin to “feel” bottom as they approach shallow water. As they approach the breaking point, they can reach heights of 75 to 100 feet. It is important to note not all earthquakes, regardless of the strength, will result in a Tsunami. Generally, it is believed the sudden “drop” of a tectonic plate is the cause of such energy. The typical “shaking from side to side” does not necessarily generate the focused energy required to create a Tsunami of great strength. Unfortunately, because Tsunami’s travel so fast and there is not ample time to evaluate the area of the disturbance, local officials must assume the worst and prepare for a possible Tsunami.

Unless the undersea disturbance occurs in the near vicinity of Okinawa, there will be adequate time to prepare. Coastal and low areas are the most susceptible. The Detachment is inland and 157 feet above sea level. Therefore, it is best to remain in building 3674. Personnel and families in low-lying areas should evacuate to higher ground upon word from base officials.

11. Acoustics

A complete review of ocean thermal properties, acoustic properties, and resulting sound propagation characteristics is beyond the scope of this handbook. Water mass characteristics affect sound propagation paths; therefore, knowledge of oceanographic features and how each may be exploited to it's maximum extent is imperative. As outlined earlier, many oceanographic features can be found in the Detachment's AOR. As such, the remainder of this section will briefly review ocean features and their tactical implications.

a. Sound Channels. Sound channeling caused by surface ducts, shallow sound channels (SSC), or Deep Sound Channels (DSC), is exploitable. Deep Sound Channels are often difficult to access yet may prove operationally effective if a receiver can be placed within the mid-three quarters of the DSC. Shallow Sound Channels may not be geographically widespread, hence not tactically useful. However, they may exist around fronts and provide extended ranges if a sound source is placed in the channel. The cut-off frequency of sound channels will help determine their tactical significance. If the frequency of interest is above the cut-off value, then extended ranges may be expected. Frequencies twice the cut-off value are more reliably ducted. Frequencies below the cut-off value will not be ducted.

b. Fronts. Fronts will vary the SLD, Below Layer Gradient (BLG), horizontal gradient, and overall sound speed. When moving from the warm side into the cold side of a front, the axis of the SLD and DSC will shallow significantly. In many cases, the SLD will become so shallow that exploitation of the SSC is no longer feasible. Very steep sound speed "slopes" on the warm side will result in the downward refraction of sound rays which can often increase multi-path detection. In the immediate vicinity of the front, other factors such as increased ambient noise and reverberation (due to increased biologics and fishing vessels), and increased sea state may be expected. Of particular interest is the North Wall Effect. This phenomena occurs during winter when dry cP air passes over the warm water carried by the Kuroshio Extension. The extreme temperature discontinuity results in rapid vertical movement of air promoting CB build-up. Extremely strong gusty winds and unstable conditions result in poor flying conditions, buoy wash-over, and high ambient noise. One factor often overlooked in inclement weather, the radio interference between buoy and aircraft is high, resulting in less area covered by the patrolling P-3 aircraft.

c. Eddies. These are best conceptualized as circular fronts. Warm core eddies are easily detected on the cold side of a current with the use of infrared (IR) imagery. The cold core eddy is more difficult to locate using IR because they contain denser water than the surrounding waters and the eddy tends to sink, or their surface becomes heated through insolation, reducing the thermal contrast.

(1) Warm Core. They are usually found near the surface due to the core properties of the eddy being less dense then the surrounding water. This also allows them to be detected for longer periods. The SLD will deepen as you move toward the center. The changes are dramatic

and operationally significant. A sound source in the center of a warm eddy will have good direct path ranges because the increased likelihood of ducting. However, detection across the eddy's edge may only be possible through CZ and bottom bounce propagation paths.

(2) Cold Core. The cold core eddy is an acoustic "lens", betraying targets at any depth as long as the source and receiver are in the same water type. Like the cold side of a front, the DSC shallows and becomes more accessible. The SLD will shoal to such a shallow depth, it will be of limited use for trapping.

d. Topographic Effects. The theory of upslope and downslope enhancement depends upon the slope of the ocean floor. Due to the high bottom loss regions, very steep slopes, and high ambient noise found in this area, P-3 assets have shown very little tactical advantage to be gained using upslope / downslope enhancement theories. However, due to the steep slopes, signal noise may be impeded by the rapidly rising bathymetry. It is more likely that upslope / downslope enhancement and topographic stripping is more of an advantage to the submarine than airborne USW assets.

(1) Upslope. Sound rays transmitted up a moderately steep slope will display increasing arrival angles with each bottom interaction, thus increasing chances of multipath detection.

(2) Downslope. Downslope enhancement relies on sound rays propagating down the slope, eventually transforming from a bottom bounce to a DSC propagation.

CHAPTER III
MONTHLY CLIMATOLOGICAL SUMMARIES

A. January: During this month, the polar front is situated well south of Okinawa over the Bashi Channel. Cold weather "out-breaks" developing from the Siberian high are modified when they reach warm water off the East China Sea. Okinawa's daily minimum temperature rarely drops below 45 F as a result. Shanghai lows develop and move in an east-northeasterly direction, passing just north of Okinawa bringing inclement weather.

1. Probability of typhoons
    (a) TCCOR3 upgrade on Okinawa……………………….. 0%
    (b) Direct hit on Okinawa (Setting of TCCOR1)………… 0%

2. Sky Condition
    (a) Ceiling above 3000' and / or 3 miles visibility……….. 96%
    (b) Ceiling below 3000' and / or 3 miles visibility……….. 3.7%
    (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.3%
    (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
    (a) Average precipitation………………………………….. 4.4 inches
    (b) Mean number of days with .01 inches or more……….. 13 days
    (c) Maximum monthly precipitation……………………….13.1 inches
    (d) Minimum monthly precipitation………………………. 0.09 inches
    (e) Maximum precipitation in a 24 hour period……………9.05 inches

4. Temperature and Humidity
    (a) Average daily temperature……………………………. 65 F
    (b) Extreme maximum temperature………………………. 84 F
    (c) Mean maximum temperature…………………………. 70 F
    (d) Mean minimum temperature…………………………. 59 F
    (e) Extreme minimum temperature………………………. 42 F
    (f) Mean relative humidity…………………………… …….. 71%

5. Wind
    (a) Most frequent direction / mean speed………………… ENE / 8 KTS
    (b) Mean maximum monthly gust……………………….. 33 KTS
    (c) Maximum gust………………………………………… 42 KTS

6. Miscellaneous
    (a) Thunderstorm days…………………………………….. 1
    (b) Average sea surface temperature……………………… 73 F

B. February: The Siberian high reaches its maximum intensity. Daily weather follows a cyclic pattern of approximately 3 to 8 days. Precipitation continues to be associated with cold air (warm water) stratocumulus, frontal passage, and unstable waves along frontal boundaries. Taiwan lows are an important influence on the weather over Okinawa.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa……………………… 9%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 0%

2. Sky Condition
   (a) Ceiling above 3000' and / or 3 miles visibility……….. 90%
   (b) Ceiling below 3000' and / or 3 miles visibility……….. 9.1%
   (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.6%
   (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
   (a) Average precipitation………………………………….. 4.6 inches
   (b) Mean number of days with .01 inches or more……….. 14 days
   (c) Maximum monthly precipitation……………………….10.2 inches
   (d) Minimum monthly precipitation………………………. 0.71 inches
   (e) Maximum precipitation in a 24 hour period……………5.05 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 62 F
   (b) Extreme maximum temperature………………………. 83 F
   (c) Mean maximum temperature…………………………. 67 F
   (d) Mean minimum temperature…………………………. 56 F
   (e) Extreme minimum temperature………………………. 37 F
   (f) Mean relative humidity…………………………… …….. 73%

5. Wind
   (a) Most frequent direction / mean speed………………… N / 8 KTS
   (b) Mean maximum monthly gust……………………….. 39 KTS
   (c) Maximum gust……………………………………….. 54 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 1
   (b) Average sea surface temperature……………………… 70 F

C. March: During March, the polar front begins its annual retreat northward. The Siberian high begins to weaken quite rapidly and moves northward. Frequent lows develop in the vicinity of Shanghai and track towards the northeast. Associated frontal systems of the Shanghai low occasionally pass over Okinawa. Taiwan lows are still a frequent occurrence.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa……………………… 15%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 1%

2. Sky Condition
   - (a) Ceiling above 3000’ and / or 3 miles visibility……….. 81%
   - (b) Ceiling below 3000’ and / or 3 miles visibility……….. 16.6%
   - (c) Ceiling below 1000’ and / or 2 miles visibility……….. 1.9%
   - (d) Ceiling below 200’ and / or 1/2 mile visibility……….. 0.0%

3. Weather
   - (a) Average precipitation………………………………….. 6.1 inches
   - (b) Mean number of days with .01 inches or more……….. 16 days
   - (c) Maximum monthly precipitation……………………….19.4 inches
   - (d) Minimum monthly precipitation………………………. 0.94 inches
   - (e) Maximum precipitation in a 24 hour period……………6.52 inches

4. Temperature and Humidity
   - (a) Average daily temperature……………………………. 65 F
   - (b) Extreme maximum temperature………………………. 82 F
   - (c) Mean maximum temperature…………………………. 70 F
   - (d) Mean minimum temperature…………………………. 59F
   - (e) Extreme minimum temperature………………………. 39 F
   - (f) Mean relative humidity……………………… …….. 78%

5. Wind
   - (a) Most frequent direction / mean speed………………… N / 8 KTS
   - (b) Mean maximum monthly gust……………………….. 36 KTS
   - (c) Maximum gust………………………………………… 48 KTS

6. Miscellaneous
   - (a) Thunderstorm days…………………………………….. 2
   - (b) Average sea surface temperature……………………… 72 F

D. April: The Siberian high has lost its energy and no longer becomes a cold, windy weather threat to Okinawa. Polar front passage is less frequent but still oscillates north and south of Okinawa. Unstable waves along this boundary pass near the island providing for precipitation. The Pacific high begins to relocate to the northwest and the monsoonal trough, near the equator, becomes increasingly active promoting the development of tropical cyclones.

1. Probability of typhoons
   - (a) TCCOR3 upgrade on Okinawa………………………. 37%
   - (b) Direct hit on Okinawa (Setting of TCCOR1)………… 2%

2. Sky Condition
   - (a) Ceiling above 3000’ and / or 3 miles visibility……….. 79%
   - (b) Ceiling below 3000’ and / or 3 miles visibility……….. 18.2%
   - (c) Ceiling below 1000’ and / or 2 miles visibility……….. 2.8%

(d) Ceiling below 200’ and / or 1/2 mile visibility……….. 0.0%

3. Weather
   (a) Average precipitation………………………………….. 6.5 inches
   (b) Mean number of days with .01 inches or more……….. 13 days
   (c) Maximum monthly precipitation……………………….19.1 inches
   (d) Minimum monthly precipitation………………………. 0.70 inches
   (e) Maximum precipitation in a 24 hour period……………4.56 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 70 F
   (b) Extreme maximum temperature………………………. 88 F
   (c) Mean maximum temperature…………………………. 75 F
   (d) Mean minimum temperature…………………………. 65 F
   (e) Extreme minimum temperature………………………. 46 F
   (f) Mean relative humidity……………………… …….. 80%

5. Wind
   (a) Most frequent direction / mean speed………………… ENE / 8 KTS
   (b) Mean maximum monthly gust……………………….. 40 KTS
   (c) Maximum gust………………………………………… 56 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 3
   (b) Average sea surface temperature……………………… 73 F

E. May: The mean position of the polar front is north of Okinawa. The Pacific high is building and the Siberian high is weakening. The resultant low-level wind shear from the interaction of these two high pressure systems creates the Transitional Convergence Zone (TCZ), a wide band of convective activity, which marks the beginning of the rainy season and is the transition from winter to summer (spring). Light to moderate rain and / or low ceilings occur nearly every day during the rainy season. This transition can last well into the month of June on Okinawa. As the Pacific high continues to build, the TCZ will migrate north. Tropical cyclone development becomes more frequent as the monsoonal trough deepens near the equator. Tropical cyclones begin to track around the periphery of the Pacific high in the vicinity of Okinawa.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa………………………. 34%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 10%

2. Sky Condition
   (a) Ceiling above 3000’ and / or 3 miles visibility……….. 75%
   (b) Ceiling below 3000’ and / or 3 miles visibility……….. 20%
   (c) Ceiling below 1000’ and / or 2 miles visibility……….. 4.2%
   (d) Ceiling below 200’ and / or 1/2 mile visibility……….. 0.2%

3. Weather
   (a) Average precipitation………………………………….. 9.9 inches
   (b) Mean number of days with .01 inches or more……….. 15 days
   (c) Maximum monthly precipitation………………………26.8 inches
   (d) Minimum monthly precipitation………………………. 0.58 inches
   (e) Maximum precipitation in a 24 hour period……………6.11 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 75 F
   (b) Extreme maximum temperature………………………. 91 F
   (c) Mean maximum temperature…………………………. 80 F
   (d) Mean minimum temperature…………………………. 70 F
   (e) Extreme minimum temperature………………………. 53 F
   (f) Mean relative humidity………………………… …….. 81%

5. Wind
   (a) Most frequent direction / mean speed………………… E / 8 KTS
   (b) Mean maximum monthly gust……………………….. 32 KTS
   (c) Maximum gust………………………………………… 39 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 3
   (b) Average sea surface temperature……………………… 77 F

F. June: Within the first half of the month, the Transitional Convergence Zone migrates north toward Kyushu marking the end of the rainy season for Okinawa. The summer monsoon is established and typhoon season begins. The second half of the month is dominated by hot, humid weather as the Pacific high builds well over Okinawa into eastern China.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa……………………… 35%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 18%

2. Sky Condition
   (a) Ceiling above 3000' and / or 3 miles visibility……….. 84%
   (b) Ceiling below 3000' and / or 3 miles visibility……….. 14%
   (c) Ceiling below 1000' and / or 2 miles visibility……….. 2.1%
   (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
   (a) Average precipitation………………………………….. 11.1 inches
   (b) Mean number of days with .01 inches or more……….. 15 days
   (c) Maximum monthly precipitation………………………30.7 inches
   (d) Minimum monthly precipitation………………………. 0.92 inches

(e) Maximum precipitation in a 24 hour period…………..9.43 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 80 F
   (b) Extreme maximum temperature………………………. 95 F
   (c) Mean maximum temperature…………………………. 85 F
   (d) Mean minimum temperature…………………………. 76 F
   (e) Extreme minimum temperature………………………. 62 F
   (f) Mean relative humidity………………………… …….. 85%

5. Wind
   (a) Most frequent direction / mean speed………………… WSW / 8 KTS
   (b) Mean maximum monthly gust.……………………….. 47 KTS
   (c) Maximum gust………………………………………… 68 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 4
   (b) Average sea surface temperature……………………… 78 F

G. July: The polar front has reached its summer position, extending from South Korea to northern Honshu. The rainy season for central Japan has begun. Hot, humid conditions continue to prevail for Okinawa. The main source of precipitation is from tropical cyclones. 95% of all tropical cyclones that develop in the North Pacific form southeast of Guam.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa………………………. 44%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 18%

2. Sky Condition
   (a) Ceiling above 3000' and / or 3 miles visibility……….. 95%
   (b) Ceiling below 3000' and / or 3 miles visibility……….. 4.4%
   (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.7%
   (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.1%

3. Weather
   (a) Average precipitation………………………………….. 7.13 inches
   (b) Mean number of days with .01 inches or more……….. 12 days
   (c) Maximum monthly precipitation………………………19.4 inches
   (d) Minimum monthly precipitation……………………… 0.54 inches
   (e) Maximum precipitation in a 24 hour period……………9.46 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 84 F
   (b) Extreme maximum temperature………………………. 97 F
   (c) Mean maximum temperature…………………………. 89 F

(d) Mean minimum temperature………………………… 79 F
(e) Extreme minimum temperature……………………… 70 F
(f) Mean relative humidity…………………… …….. 82%

5. Wind
(a) Most frequent direction / mean speed………………… WSW / 8 KTS
(b) Mean maximum monthly gust.……………………….. 56 KTS
(c) Maximum gust……………………………………… 89 KTS

6. Miscellaneous
(a) Thunderstorm days………………………………….. 3
(b) Average sea surface temperature……………………… 83 F

H. August: The Pacific high has reached maximum intensity. Afternoon showers from maximum heating and evening / early morning showers from nocturnal cooling are common. The monsoonal trough is at its northern most position over central Philippines. Development of tropical cyclones within 72 hours of Okinawa is highly possible. August is the peak month for tropical cyclone activity over Okinawa.

1. Probability of typhoons
(a) TCCOR3 upgrade on Okinawa (first half of month)…. 40%
(b) TCCOR3 upgrade on Okinawa (second half of month) 50%
(c) Direct hit on Okinawa (Setting of TCCOR1)………… 22%

2. Sky Condition
(a) Ceiling above 3000' and / or 3 miles visibility……….. 93%
(b) Ceiling below 3000' and / or 3 miles visibility……….. 6.2%
(c) Ceiling below 1000' and / or 2 miles visibility……….. 0.8%
(d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
(a) Average precipitation……………………………….. 10.5 inches
(b) Mean number of days with .01 inches or more……….. 16 days
(c) Maximum monthly precipitation………………………27.3 inches
(d) Minimum monthly precipitation……………………… 2.22 inches
(e) Maximum precipitation in a 24 hour period……………11.0 inches

4. Temperature and Humidity
(a) Average daily temperature……………………………. 84 F
(b) Extreme maximum temperature……………………… 95 F
(c) Mean maximum temperature…………………………. 88 F
(d) Mean minimum temperature………………………… 79 F
(e) Extreme minimum temperature………………………. 69 F
(f) Mean relative humidity…………………… …….. 83%

5. Wild
   (a) Most frequent direction / mean speed………………… WSW / 8 KTS
   (b) Mean maximum monthly gust……………………….. 62 KTS
   (c) Maximum gust……………………………………… 96 KTS

6. Miscellaneous
   (a) Thunderstorm days………………………………….. 3
   (b) Average sea surface temperature……………………… 83 F

I. September: Summer comes to an end and the transition to winter begins (Autumn). This is the second rainy season for Okinawa. A weak high will appear over Asia and the Pacific high begins to recede to its winter location. Like the Transitional Convergence Zone (TCZ) from spring, the resultant low-level wind shear from the interaction of these two systems is re-created. It is short-lived and not as intense as the spring-time TCZ. By the end of the month, the northeast monsoon is fully established and the polar front is making its seasonal trek south. The threat of tropical cyclones is still very high.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa………………………. 31%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 15%

2. Sky Condition
   (a) Ceiling above 3000' and / or 3 miles visibility……….. 94%
   (b) Ceiling below 3000' and / or 3 miles visibility……….. 5.6%
   (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.8%
   (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
   (a) Average precipitation………………………………….. 7.94 inches
   (b) Mean number of days with .01 inches or more……….. 13 days
   (c) Maximum monthly precipitation………………………57.6 inches
   (d) Minimum monthly precipitation………………………. 0.96 inches
   (e) Maximum precipitation in a 24 hour period……………42.2 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 82 F
   (b) Extreme maximum temperature………………………. 93 F
   (c) Mean maximum temperature…………………………. 87 F
   (d) Mean minimum temperature…………………………. 76 F
   (e) Extreme minimum temperature………………………. 64 F
   (f) Mean relative humidity…………………………… …….. 82%

5. Wind
   (a) Most frequent direction / mean speed………………… ENE / 8 KTS
   (b) Mean maximum monthly gust……………………….. 53 KTS

(c) Maximum gust………………………………………… 83 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 3
   (b) Average sea surface temperature……………………… 83 F

J. October: The Siberian high continues to build over Mongolia. The northeast monsoon brings cooler temperatures and less humidity to Okinawa. The mean position of the polar front is situated south of Okinawa, which increases the frequency of Taiwan lows passing over the island. The tropical cyclone season is coming to an end, but the cyclones still pose a threat to the area.

1. Probability of typhoons
   (a) TCCOR3 upgrade on Okinawa………………………. 23%
   (b) Direct hit on Okinawa (Setting of TCCOR1)………… 18%

2. Sky Condition
   (a) Ceiling above 3000’ and / or 3 miles visibility……….. 93%
   (b) Ceiling below 3000’ and / or 3 miles visibility……….. 6.2%
   (c) Ceiling below 1000’ and / or 2 miles visibility……….. 0.7%
   (d) Ceiling below 200’ and / or 1/2 mile visibility……….. 0.0%

3. Weather
   (a) Average precipitation………………………………….. 6.59 inches
   (b) Mean number of days with .01 inches or more……….. 11 days
   (c) Maximum monthly precipitation……………………….35.0 inches
   (d) Minimum monthly precipitation………………………. 0.71 inches
   (e) Maximum precipitation in a 24 hour period……………10.2 inches

4. Temperature and Humidity
   (a) Average daily temperature……………………………. 76 F
   (b) Extreme maximum temperature………………………. 90 F
   (c) Mean maximum temperature…………………………. 82 F
   (d) Mean minimum temperature…………………………. 71 F
   (e) Extreme minimum temperature………………………. 53 F
   (f) Mean relative humidity……………………………….. 76%

5. Wind
   (a) Most frequent direction / mean speed………………… ENE / 9 KTS
   (b) Mean maximum monthly gust……………………….. 65 KTS
   (c) Maximum gust………………………………………… 108 KTS

6. Miscellaneous
   (a) Thunderstorm days…………………………………….. 1

(b) Average sea surface temperature………………………. 81 F

K. <u>November:</u> Northern Japan will experience their first snow of the season. The Siberian high is becoming stronger and central Honshu is experiencing cold outbreaks as a result. Okinawa can expect the passage of 4 to 8 Taiwan lows during this month. The primary feature of these systems is the strong northerly winds after passage. These winds gust from 25 to 35 knots, usually for periods of 48 hours.

1. <u>Probability of typhoons</u>
   - (a) TCCOR3 upgrade on Okinawa………………………. 23%
   - (b) Direct hit on Okinawa (Setting of TCCOR1)………… 7%

2. <u>Sky Condition</u>
   - (a) Ceiling above 3000' and / or 3 miles visibility……….. 95%
   - (b) Ceiling below 3000' and / or 3 miles visibility……….. 5.2%
   - (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.3%
   - (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. <u>Weather</u>
   - (a) Average precipitation………………………………….. 5.10 inches
   - (b) Mean number of days with .01 inches or more……….. 12 days
   - (c) Maximum monthly precipitation……………………….17.1 inches
   - (d) Minimum monthly precipitation………………………. 0.31 inches
   - (e) Maximum precipitation in a 24 hour period……………9.78 inches

4. <u>Temperature and Humidity</u>
   - (a) Average daily temperature……………………………. 71 F
   - (b) Extreme maximum temperature………………………. 88 F
   - (c) Mean maximum temperature…………………………. 76 F
   - (d) Mean minimum temperature…………………………. 65 F
   - (e) Extreme minimum temperature………………………. 50 F
   - (f) Mean relative humidity………………………… …….. 75%

5. <u>Wind</u>
   - (a) Most frequent direction / mean speed………………… ENE / 9 KTS
   - (b) Mean maximum monthly gust.……………………….. 57 KTS
   - (c) Maximum gust………………………………………… 89 KTS

6. <u>Miscellaneous</u>
   - (a) Thunderstorm days…………………………………….. 1

(b) Average sea surface temperature………………………… 77 F

L. December: Siberian high pressure dominates the weather for Japan (including Okinawa). Bubble highs frequently "break-off" from the Siberian high and follow a track to the southeast. If the axis of a bubble high is south of 35N, fair weather can be expected over Okinawa. If the axis is north of 35N, inclement weather can be expected.

1. Probability of typhoons
   - (a) TCCOR3 upgrade on Okinawa……………………….. 18%
   - (b) Direct hit on Okinawa (Setting of TCCOR1)………… 8%

2. Sky Condition
   - (a) Ceiling above 3000' and / or 3 miles visibility……….. 96%
   - (b) Ceiling below 3000' and / or 3 miles visibility……….. 3.7%
   - (c) Ceiling below 1000' and / or 2 miles visibility……….. 0.3%
   - (d) Ceiling below 200' and / or 1/2 mile visibility……….. 0.0%

3. Weather
   - (a) Average precipitation………………………………….. 4.44 inches
   - (b) Mean number of days with .01 inches or more……….. 13 days
   - (c) Maximum monthly precipitation……………………….13.8 inches
   - (d) Minimum monthly precipitation……………………… 0.09 inches
   - (e) Maximum precipitation in a 24 hour period……………9.05 inches

4. Temperature and Humidity
   - (a) Average daily temperature……………………………. 65 F
   - (b) Extreme maximum temperature……………………… 84 F
   - (c) Mean maximum temperature…………………………. 70 F
   - (d) Mean minimum temperature…………………………. 59 F
   - (e) Extreme minimum temperature……………………… 42 F
   - (f) Mean relative humidity……………………… …….. 71%

5. Wind
   - (a) Most frequent direction / mean speed………………… ENE / 8 KTS
   - (b) Mean maximum monthly gust……………………….. 34 KTS
   - (c) Maximum gust……………………………………… 42 KTS

6. Miscellaneous
   - (a) Thunderstorm days…………………………………….. 1

(b) Average sea surface temperature……………………… 73 F

CHAPTER IV

FORECASTING

A. METOC Forecasts

The 18th Operations Support Squadron is the official reporting station for the base. However, the Detachment still has a responsibility to provide the operating forces, (Sailor's, Airmen, Marines, and DON Personnel), with the highest quality METOC products and services to best prepare them to go anywhere, anytime, to successfully defend the nation's interests and survive. Therefore, it is essential the METOC Forecaster have a thorough understanding of meteorological forecasting techniques, as well as oceanographic forecasting techniques, for Okinawa and the Detachment's AOR.

B. Rules of Thumb

The following forecasting techniques are based on local forecaster observations of certain variables that generally signal a specific METOC condition or event taking place. They are by no means the only indicators of changing conditions and all variables should be taken into account when preparing a forecast.

1. Spring.

a. Stratus. Caused by the cooling of moist southerly airflow over cooler water. Generally it is less than 1000 feet thick, with bases between 500 and 1000 feet.

(1) Fog over water to the south-southwest lifts as it's advected over the island's edge, then prevails as stratus until dissipation 2 to 3 hours after sunrise. This situation is intensified when the southerly flow is 10 to 20 knots, causing rapid cooling of the air and lowering the mixing condensation level (MCL).

(2) During the early morning hours, a tight surface pressure gradient producing strong northerly winds, in conjunction with a strong inversion in the lower level of the continental polar air mass produces stratus. This forms as warm moist surface air over the ocean is advected over the cooler land of Okinawa. It will be scattered to broken shortly after sunset.

When winds are from the southeast through the south, it will produce a scattered to broken layer of stratus over the island. Under these conditions, stratus is quite variable and burns off rapidly after sunrise. Once burned off, a scattered to broken deck of stratocumulus with bases at 1500 to 2500 feet will develop by late morning.

If winds are northerly, it will be broken to overcast stratocumulus clouds at 1500 to 4000 feet over the island. Cloudy conditions will persist through the day. Clearing will occur only if, and when, the daytime heating breaks down the surface inversion.

(3) With light low-level winds, stratus generally remains as a scattered layer over the island until sunrise. When weak surface heating over Okinawa results in moist offshore air to be advected onto land, the layer becomes broken two to four hours afterward, lifting from a base of 600 feet to a base of 1800 feet by noon. In this case, the cloud cover is generally independent of wind direction, making it difficult to forecast the amount of cloud cover and timing of ceiling periods.

(4) Forecast stratus when the winds from the surface to 2000 feet are greater than 10 knots. By noon, the stratus ceiling will be below 1000 feet and will be an intermittent condition, both in the amount of coverage and in height. It will remain until the surface temperature has risen 6 degrees F over the minimum temperature.

b. Taiwan and Shanghai Lows

(1) When the normal westerlies aloft back to the southwest or south-southwest over Taiwan, and areas further west along the China coast, precipitation can be expected over Okinawa in 24 to 36 hours, as a result of an approaching Taiwan low.

(2) Look for a Taiwan low to develop in 24 to 36 hours when:

(a) The polar front is located south of Okinawa.

(b) There is a flat pressure gradient through Ishigaki and Taiwan.

(c) Miyako and Ishigaki surface winds are from the SE.

(d) Kadena AB reports sea level pressure less than 1015.0.

(e) The 700 MB wind flow is from the southwest over Taiwan.

(f) The sea level pressure at Minami Daito is greater than at Taipei.

(3) Most waves forming southwest of Okinawa move northeast at 12 to 15 knots. In isolated cases they move as fast as 25 to 30 knots

(4) Southwesterly winds at 700 MB over station 810 (southwest of Taiwan) during the autumn or spring indicate precipitation at Kadena within 24-36 hours.

(5) Taiwan lows usually deepen 1 millibar every three hours after they form. They intensify 1 millibar every hour after reaching the southern coast of Kyushu.

(6) A Taiwan low will move eastward across the Ryukyu Islands about 24 hours after east-southeast winds are observed at Miyako and Ishigaki.

(7) After a Taiwan low forms and moves northeast, Miyako and Ishigaki will be in the cold sector behind the front and experience fair weather.

(8) When a Taiwan low moves northeast, cold frontal passage at Kadena usually occurs within 24 hours after warm frontal passage. A squall line usually precedes the cold front, acting as a false frontal passage. Thunderstorms commonly accompany this squall line.

(9) As a Taiwan low moves towards Okinawa, Kadena experiences warm frontal type weather. After warm frontal passage, expect the cold front to pass 5 to 6 hours after Miyako indicates cold frontal passages.

(10) Light rain will begin on Okinawa 3 to 6 hours after a cloud pattern east-northeast of Taiwan indicates deepening and definite movement.

(11) As the wave from a Taiwan low passes to the south of Okinawa, expect showers and associated low ceilings.

(12) In some cases, Taiwan lows develop, deepen, and move through the Okinawa area in less than 24 hours. This rapidly moving system usually develops during the night and will be through the area by sunset the following evening.

(13) Shanghai lows move at a speed of 20 to 40 knots north-northeast and then east-northeast, roughly parallel and adjacent to the Kuroshio current.

(14) Unstable waves forming east of Shanghai will cause low ceilings and visibility throughout south and central Japan. When the associated cold front passes Ishigaki and Miyako, the front will pass through Okinawa 6 to 8 hours later.

c. Fog. Although rare on Okinawa, there are times when it does occur.

(1) Patchy ground fog occurs in moist low areas on nights with good radiational conditions.

(2) During periods of heavy and prolonged precipitation, fog forms due to total saturation of the ground and lower levels of the atmosphere.

(3) During pre-warm frontal weather, a fog bank can form to the south-southwest, obscuring Naha. The bank lifts slightly over Kadena, and reduces visibility to one mile or less.

2. <u>Summer</u>

a. The period considered "summer weather" extends from the time of the last polar outbreak in late June, after which the polar front moves north of Okinawa. Climatologically averaged to be the third week in June, until the time of the first frontal passage in September.

b. Except for typhoons, early morning stratus, and afternoon / evening thunderstorms over the island, good summer weather prevails over Okinawa. This is caused by the building of the Pacific high, which is located along 25N-30N to the east of the Ryukyu Islands and extends beyond Okinawa to the Chinese mainland.

c. Prevailing summer winds are southerly and are light and variable during the period from sunset to sunrise. They increase during the early morning to 10 to 20 knots, and remain at that speed until early evening.

d. Thunderstorms are difficult to forecast. Most often, they are caused by the decrease of the surface to 500 MB wind speed to light and variable, which allows for increased vertical development of clouds. During the day, cumulus clouds build over the island and having no strong flow to advect them out, develop into thunderstorms. Waterspouts and funnel clouds are common during this period but cause little or no damage. Reports of waterspouts over Buckner Bay from towering cumulus, some with tops below 20,000 feet are common. There have been a few occurrences of funnel clouds over the hills at Camp Hansen and points further up the island with some touching down as weak and short-lived tornadoes.

e. During the first week after the polar front has moved north of Okinawa (usually 15 to 20 June), and while the island is still saturated from the spring rains, the occurrence of fog has been observed under the following conditions:

(1) The low level winds are south-southwest at 10 to 20 knots.

(2) A low level inversion is present, capping a deck of stratus with a base of 700 to 1000 feet.

(3) Ceilings of less than 500 feet and visibility of less than 5 miles occur.

f. At night, when the low-level winds are light and variable, with a calm surface wind around sunset, expect a drainage wind to develop from the northeast to east and smoke to drift into the area from the Koza dump. This can be a problem with visibility to the east through northeast quadrants, but seldom reduces the overall prevailing visibility.

3. <u>Autumn</u>

a. Autumn weather, which extends from the first cold frontal passage during September to mid-December, is variable. Early frontal passages usually contain imbedded thunderstorms, and become weak and disorganized to the south (around Miyako Island).

b. Excellent weather generally prevails for a two or three day period after frontal passage.

c. Typhoons occur frequently during this period, and will, if passing near Okinawa, change the polar front position and associated air mass over the island.

d. Frontal passages during early autumn have a 4 to 6 day cycle. Later in the season, this is reduced to a 2 to 4 day cycle.

e. Autumn frontal passages are usually brief. Associated weather is 4 to 6 hours of light rain.

f. After cold frontal passage, showers will occur about 3 to 4 hours later.

g. Weather approaching Kadena AB will be the same weather experienced by Naze (station 909).

h. When a Siberian high moves toward central China, crosses 110E and reaches the mouths of the Yangtze and Yellow Rivers, the trough ahead of the high will cross the Ryukyu Islands.

i. A cold front will pass Okinawa in 24 hours when:

(1) Temperature advection below 500 MB changes from cold to warm (veering winds with height); and

(2) Southerly winds appear in the layer between 4000 and 7000 feet.

j. Mid-level clouds will generally constitute a ceiling, but are usually thin, around 2000 feet thick. Bases may vary between 8000 and 16,000 feet. These clouds usually burn off with daytime (diurnal) heating. The best indicator of their formation is a thin layer of moisture on the 1200Z sounding, capped by very dry air above.

4. <u>Winter</u>

a. Mid-December through mid-February is the period of the "arctic fronts", as the main atmospheric polar front lies across the Philippines.

b. The most significant weather phenomena during this season are the post-frontal gusty surface winds.

c. When a Siberian high outbreak is evident, forecast surface winds of at least 20 knots with gusts to 35 knots at the time of frontal passage. There may also be a second surge of gusty winds which reach 40+ knots occurring 1 to 2 hours after frontal passage.

d. Low ceilings (900 to 1500 feet) extend far behind intense cold fronts.

e. Although quite rare, thunderstorms with low tops (18,000 to 25,000 feet) may accompany a rapid-moving intense cold front.

f. Surface wind intensity varies with the width of weather bands. Narrow, rapid-moving bands are accompanied by gusts to 45 knots, while wide, slow moving weather bands may be accompanied by gusts which seldom exceed 35 knots.

g. When the surface wind at Kadena AB gusts above 25 knots, low level turbulence at Ie Shima and over northern Okinawa becomes moderate to occasionally severe from the surface to 4000 feet.

h. Jet aircraft reports of moderate CAT north of Kadena usually follow frontal passage at Kadena.

i. In forecasting weather associated with outbreaks of the Siberian high:

(1) Prior to frontal passage, surface winds will become southwest to west, 20 to 35 knots and gusting in isolated cases to 65 knots.

(2) The cold front will be moving at speeds in excess of 20 knots.

(3) Rain will occur prior to passage of the front with rain showers for at least six hours subsequent to passage.

(4) During cold frontal passage, classic wind shifts from southwesterly to northwest occur. The ceiling may be reduced as low as 500 feet and visibility may be less than a mile in heavy rain and rain showers.

(5) Behind the front are persistent, strong gusty surface winds often 25 knots or higher and 1 to 3 days of overcast stratocumulus with bases between 2000 and 6000 feet. Occasional light rain showers or drizzle will accompany the overcast skies. This precipitation will usually end when winds decrease and shift to the northeast to north.

j. Frequently, scattered convective showers occur over water during post frontal northerly flow as a result of strong surface heating on the relatively warm water surrounding Okinawa.

k. During the winter months, even though the sky cover is scattered to clear at sunset, forecast a broken to overcast deck of stratocumulus with bases between 3000 and 4000 feet and tops between 5000 and 6000 feet, forming under a very strong inversion by midnight. This deck will persist until one to two hours after sunrise, then become scattered.

l. Dust (yellow sand) can occur 2 to 3 days after intense cold frontal passages. This dust is first observed over the Gobi desert and with continued strong northwest flow in the upper levels, will move over Okinawa. Visibility may be reduced as low as 2 to 3 miles in dust and haze.

m. In January and February, forecast good weather when a migrating high center moves east along or south of 30N.

n. When a migrating high reaches the vicinity of 30N and 150E, the subsequent cold front will pass over the Ryukyu Islands.

o. When minor troughs aloft are located well behind the surface trough, most of the rain and low ceilings experienced will be post-frontal.

p. When the trough aloft is almost vertically located over the surface front, most of the rain and low ceilings experienced will be pre-frontal, with rapid improvement occurring a few hours after frontal passage.

q. A polar frontal passage at Kadena can be expected to occur within 16 hours after it passes Cheju-Do if the 700 MB wind speed at Kadena (at the time of the frontal passage over Cheju-do) was 25 knots or greater.

r. The cold front of a single low in the Sea of Japan will cross Okinawa as the low center passes over the Noto Peninsula (37N and 137E).

s. In crew briefings during November through February, the following points should be emphasized:

(1) With strong winds over Japan, flowing in a direction perpendicular to the mountains, severe to extreme turbulence is experienced over the Kanto Plain.

(2) Icing becomes a problem for propeller-type aircraft over routes extending northward to Korea, Japan, Midway, and Alaska.

(3) Reports of moderate to severe turbulence above 20,000 feet are common north of Okinawa. Wind speeds aloft can double in 12 hours and increase to over 200 knots near the jet core, creating tremendous horizontal and vertical wind shear.

t. During the winter months, the daily temperature spread is roughly 10F. In the case of strong, cold frontal passage, the spread may increase to 17F to 21F.

u. Eighty percent of the cold fronts approaching Okinawa from the northwest are inactive and fast-moving (25 knots). Some have been observed at speeds close to 50 knots.

v. In January, Okinawa is under the influence of two jet streams. One begins near the Siberian High over central China. This jet extends across the Yellow Sea, southern Korea, and southern Honshu. When this jet migrates over the warm Kuroshio current in the East China Sea, cyclogenesis over a large area takes place. This jet is responsible for the formation of Shanghai lows.

Another jet begins near Hainan Island. It extends over Taiwan and Okinawa then passes over the northern jet stream near the mid-Honshu region. This jet has two areas that are major regions of cyclogenesis. The first is at a point where it encounters the warm Tsushima and Kuroshio currents near Taiwan and as a result, is responsible for the formation of Taiwan lows. The second area is near mid-Honshu where the two jets appear to come together over the merging warm Kuroshio and cold Oyashio currents. This area is extremely dynamic. Explosive deepening and occlusion of lows routinely occur here. Low pressure centers develop near Taiwan or Shanghai and transit along the polar front to the mid-Honshu region, where they develop into major occluded systems. Gale to storm force lows routinely develop as a result.

5. Typhoon Season

a. Typhoons are more prevalent during June through October, as the subtropical ridge builds up to 23N-27N. The area near Guam is a natural breeding ground for these storms. An indication of the approaching season is increased convective activity near the equator (Monsoonal trough).

b. As a typhoon approaches, light to moderate showers are the rule. Towering cumulus and isolated cumulonimbus clouds are common, as is their cirrostratus shield.

c. Nearer the center, the weather changes to moderate to heavy rain. Ceilings will be less than 200 feet and visibility less than one-eighth of a mile.

d. Near the eye, rain and blowing spray result in obscuration. Visibility is usually around five miles when 30 knots of wind are observed, reducing to one mile or less in heavy rain, and totally obscured when winds exceed 65 knots.

e. If under the feeder band, weather is similar to warm frontal passage with embedded CBs.

6. Special consideration for the P-3C Orion

Due to the unique mission of the P-3 Squadron, special consideration should be given to the following when providing METOC support.

a. It is very difficult to retrieve an upper air sounding in the AOR that will accurately represent the air mass used to calculate IREPS and FLIR data. Therefore, a thorough understanding of the synoptic-refractive relationship is required.

(1) High pressure center: Surface based ducts are common in all quadrants of a high pressure center. In addition to the surface based duct, the following can be expected.

(a) North of the center expect super refractive conditions

(b) Southwest of center expect higher elevated ducts

(c) Southeast of center expect low elevated ducts

(d) About and in the center expect strong ducts

(2) Low pressure center with associated frontal system

(a) In advance of a cold and warm front (eastern semi-circle of the low) expect lower ducts and sub-refractive layers.

(b) Behind a cold front (western semi-circle of the low) expect near standard conditions.

b. When processing an upper air sounding to calculate EM ranges, you must keep in mind that in most cases, the balloon was launched from dry land. The evaporation duct over land will, in some cases, be near the surface, if it exists at all. However, over water it nearly always exists. This layer is of vital importance because the P-3 receives a UHF radio signal from the buoys they drop. As a rule of thumb, if the duct is shallow (20 to 50 foot stratum) it will be strong and trap a majority of the transmitted energy from the buoy. If the stratum is deep (50 to 100 feet) the duct will be weak, allowing energy to escape from the duct and reach the aircraft.

c. If the aircraft is operating in a surface based duct, it will extend the range of the transmitting buoy. If the aircraft is flying above a surface based duct, and / or a low-level elevated duct, ranges of transmitting buoys are limited.

d. A general equation can be used to approximate nominal ranges in a generic environment. These ranges are considered "line of sight" and apply to surface contacts.

(1) Buoy range (NM) = Square root of aircraft altitude multiplied by 1.05

(2) Radar range (NM) = Square root of aircraft altitude multiplied by 1.23

(3) ESM range (NM) = Square root of aircraft altitude multiplied by 1.85

(4) Radar range example:

Aircraft altitude = 2000 feet
Aircraft altitude (squared) = 44.7
44.7 multiplied by 1.23 = 54.9
54.9 NM is the radar range at 2000 feet.

e. P-3 flights on patrol are generally VFR, as their flight level is below the CCL. An exception to this is when the area being patrolled is over very cold sea surface temperatures and 850 MB winds are light and from the south. Fog and low level stratus will prevail.

f. When on patrol, the aircraft experiences little turbulence. However, areas of strong thunderstorm activity can produce moderate to severe turbulence. Also, the threat of downburst can be disastrous due to the low flight level.

g. Buoy washover is marginal in 6 foot seas and critical in 9 to 12 foot seas.